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A SYNONYMIC LIST OF JAPANESE CHRYSOPIDÆ, WITH DESCRIPTIONS OF ONE NEW GENUS AND THREE NEW SPECIES.

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In the Journal of the College of Agriculture, Tohoku Imperial University, Vol. VI, for August, 1914, Mr. H. Okamoto has published a paper entitled "Uber die Chrysopiden-Fauna Japans," enumerating 31 species of Lace-winged flies as occurring in Japan and Formosa. I regret to say, however, that I have found that his view cannot be accepted in some cases, and at the same time I was able to discover some new forms.

This paper will include a synonymic list of Japanese Chrysopidae (excluding those that are confined to Formosa, Loo-Choo, or Bonin Island), to be followed with descriptions of new forms.

To show the points of more or less difference between the opinions of Okamoto and of myself, I present the following comparative table of the forms described or mentioned by him (left column) and those listed by me in the present paper (right column):

Nakaura matsumaræ (Okamoto) = *Apochrysa matsumaræ* Okam.
Nothochrysa olivacea Gerstaeker = *Parachrysa* (n. g.) *olivacea* (Gerst.)
Chrysopa intima M'Lach. = *Chrysopa perla intima* M'Lach.
Ch. nigriceps Okam. = *Ch. perla* L.
Ch. sapporensis Okam. = *Ch. formosa* Brauer.
Ch. inornata Matsumura = *Ch. vittata* Wesm.
Ch. nikkoensis Okam. = *Ch. sachalinensis* Mats.

The species newly added to our fauna are as follows: 1. *Apochrysa minomoana* n. sp. 2. *Chrysocerca japonica* n. sp. 3. *Chrysopa yamamuræ* n. sp. 4. *Ch. alba* Linne.

Apochrysa matsumuræ Okamoto.

Apochrysa matsumuræ Okamoto, Trans. Sappero Nat. Hist. Soc., iv, p. 13, fig. I (1912).
Nacaura[1] *matsumuræ* Navas, Rev. Russ. d' Entom., xiii, p. 280 (1913).
Nakaura matsumuræ Okamoto, Journ. Coll. Agr., Tohoku Imp. Univ., vi, p. 53 (1914).
Kagoshima (Okamoto).

Apochrysa minomoana n. sp.

Minomo near Osaka.

Nothochrysa japonica MacLachlan.

Nothochrysa japonica M'Lach., Trans. Ent. Soc. Lond., ü, p. 182 (1875).
Hondo (west of Gifu); Shikoku (Okamoto); Kinshiu; Formosa (Petersen and Okamoto).

Parachrysa (n. g.) **olivacea** (Gerstaecker).

Nothochrysa olivacea Gerstæcker, Mitt. Neu.-Verp. u. Rüg., p. 74 (1893).
Yokohama (Gerstæcker); Nikko.

Chrysocerca japonica n. sp.

Hakone.

Chrysopa perla (Linne).

Hemerobius perla Linne, Syst. Nat., Ed. 12, p. 911 (1768).
Chrysopa perla Shneider, Monog. Chrysop., p. 136, pl. 49 (1815).
Chrysopa nigriceps Okomoto, Journ. Coll. Agri., Tohoku Imp. Univ., vi, p. 58-59 (1914).
Hondo (mountainous regions); Siberia; Europe.

Chrysopa perla intima MacLachlan.

Chrysopa intima M'Lach., Trans. Ent. Soc. Lond., p. 230 (1893).
Chrysopa perla var. *fracta* Navas, Broteria, Ser. Zool. ix,, p. 39 (1910).
Saghalien; Hokkaido; Hondo (mountainous regions); Siberia.

Chrysopa lezeyi Navas.

Chrysopa lezeyi Navas, Broteria, Ser. Zool., ix, p. 42 (1910).
Sapporo, Hokkaido (Okamoto); Kofu, Hondo (Navas).

Chrysopa formosa Brauer.

Chrysopa formosa Brauer, Z. b. G., Wien, Sp. 10 (1856).
Chrysopa sapporensis Okomoto, Journ. Coll. Agr., Tohoku Imp. Univ., vi, p. 60 (1914).
Hokkaido; Hondo; Europe.

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(1) The genus *Nacaura* formed by Navás for *Apochrysa matsumuræ*, is scarcely more than a sub-genus; it has nearly all of the radial cross veins connected with one another by short cross veinlets, but they are of no generic value, since they have no stability. In *A. minomoana* n. sp., some of the cross veins in radial area of fore wing are often connected with one another, as stated in its description.

Chrysopa furcifera Okamoto.

Chrysopa furcifera Okamoto, Journ. Coll. Agr., Tohoku Imp. Univ., vi, p. 61 (1914).

Hondo; Kiushiu; Loo-Choo; Formosa.

Chrysopa vulgaris microcephala Brauer.

Chrysopa microcephala Brauer, Z. b. G., Wien, Sp. 4 (1856).

Tokyo, Kyoto, Gifu; Europe.

Chrysopa vittata Wesm.

Chrysopa vittata Wesm., Bull. Acad. Brux., viii, p. 211 (1841).
Chrysopa inornata Matsumura, Journ. Coll. Agr., Tohoku Imp. Univ., iv, p. 14 (1911).

Saghalien; Hokkaido; Hondo; Europe.

Chrysopa nipponensis Okamoto.

Chrysopa nipponensis Okamoto, Journ. Coll. Agr., Tohoku Imp. Univ., vi, p. 65-66 (1914).

Hondo; Kiushiu.

Chrysopa bipunctata Burmeister.

Chrysopa bipunctata Burm., Hand b. d. Entom., ii, p. 982 (1839).

Hondo.

Chrysopa cognata MacLachlan.

Chrysopa cognata M'Lach., Linn. Soc., ix, p. 249 (1867).
Nothochrysa robusta Gerstaecker, Mitt. Ver. Neu-Vorp. u. Rug., p. 73 (1893).
Chrysopa ricciana Navas, Rev. Russ. d' Entom., x, p. 193 (1910).

Hokkaido; Hondo; Shikoku; Kiushiu; Formosa; Siberia; China; Cambodia.

Chrysopa sauteri Petersen.

Chrysopa sauteri Petersen, Ent. Mitt., ii, p. 258 (1913).

Hondo; Formosa.

Chrysopa decorata Petersen.

Chrysopa decorata Petersen, Ent. Mitt., ii, p. 260 (1913).

Hondo; Formosa.

Chrysopa matsumurae Okamoto.

Chrysopa matsumuræ Okamoto, Journ. Coll. Agri., Tohoku Imp. Univ., vi, p. 68 (1914).

Hondo.

Chrysopa sachalinensis Matsumura.

Chrysopa sachalinensis Matsumura, Journ. Coll. Agr., Tohoku Imp. Univ., iv, p. 14 (1911).
Chrysopa nikkoënsis Okamoto, Journ. Coll. Agr., Tohoku Imp. Univ., vi, p. 69-70 (1914).

Saghalien; Hondo.

Chrysopa cognatella Okamoto.

Chrysopa cognatella Okamoto, Journ. Coll. Agri., Tohoku Imp. Univ., vi, p. 70-71 (1914).

Hokkaido; Hondo; Shikoku.

Chrysopa yamamuræ n. sp.

Gifu.

Chrysopa alba (Linne).

Hemerobius albus L., Syst. Nat., Ed. 12, p. 911 (1766).
Chrysopa alba Steph., Ill. Brit. Ent. Mand., vi, p. 204 (1836).

Gifu (Mr. S. Yamamura Coll.); Europe.

Chrysopa kurisakiana Okamoto.

Chrysopa kurisakiana Okamoto, Journ. Coll. Agr., Tohoku Imp. Univ., vi, p. 71-72 (1914).

Hondo; Kiushiu.

DESCRIPTION OF ONE NEW GENUS AND THREE NEW SPECIES.

Apochrysa minomoana n. sp.

Head greenish, paler on face; cheek with a small black spot; anterior margin of clypeus narrowly variegated with fuscous; palpi pale. Antennae much longer than fore wing, reddish brown; basal joint rather yellowish, striped with red-brown on outer side; the second joint with blackish outer side.

Prothorax much longer than broad, with a faint whitish median line; lateral sides narrowly marked with red-brown. The rest of thorax and abdomen greenish above, with a yellowish dorsal line; the third and fourth abdominal segments varied with black on lateral sides, next four segments suffused with blackish posteriorly; underside much paler.

Legs greenish, suffused with darkish on tarsi; hind femur with a distinct black ring near its end.

Fore wing very broadly hyaline, with two blackish spots as shown in figure 1, pl. VIII; venation mostly greenish, some veins in discal and outer marginal areas black; costal cross veins mostly simple, but one or two of them furcate; radial sector with about 25 branches; inner series of graduate veinlets very irregular in arrangement; several or often one or two of the cross veins between radius and its sector are connected by short cross veinlets. Hind wing with a very small, blackish spot in stigmatic region; veins greenish except those in outer marginal area; two series of gradate veinlets present.

Length of body, 14 mm.; of antennae, 35 mm.; of fore wing, 24 mm.; of hind wing, 22 mm.; width of fore wing, 10 mm.

Two female specimens, captured by Messrs. A. Nohira and M. Shibakawa at Minomo, Prov. Settsu (near Osako) in August and November, 1914, are in my collection.

Parachrysa n. gen.

Anterior margin of labrum entire. Antenna about as long as the body, shorter than the wings; the basal joint much dilated. Fore wing elongate, subacute at apex, basal part of the costal space narrow, gradually widened towards the middle of the wing; two gradate series of cross veins; the third cubital cell transversely and apparently about equally divided by a vein, which is not parallel to cubitus. Hind wing with two gradate series. Abdomen of the male with a large, peculiar-shaped subgenital plate, but without paired lateral appendages.

Type: *Nothochrysa olivacea* Gerst.

So far as the wing venation is concerned, this genus closely resembles Banks' *Allochrysa*, but I think the distinction between these two genera may be looked upon as of sufficient generic value in view of the fact that, while *Parachrysa* has a large subgenital plate, *Allochrysa* is altogether devoid of it—a sort of difference analagous to that which separates *Chrysocerca* from *Chrysopa*.

Parachrysa olivacea is a very rare insect in Japan. I have only a single male specimen which I succeeded in obtaining at Nikko, on July 19, 1914.

Chrysocerca japonica n. sp.

Head pale yellow, with no marking; maxillary palpus fuscous black, few terminal joints yellowish; labial palpus yellowish. Antennae about as long as fore wings, pale yellow; terminal joints more or less suffused with fuscous.

Prothorax somewhat longer than broad; pale yellow with greenish suffusion; meso- and meta-thorax greenish yellow with a whitish longitudinal band above. Legs pale yellow; anterior tibia somewhat brownish; claws piceous or fuscous black.

Fore wing rather broad with its apex nearly rounded. Costa, subcosta and radius pale yellow; cubitus and anal veins also pale yellow, but terminally blackish; radial sector and media pale yellow, but blackish basally and terminally; cross veins exclusively blackish; branches of radial sector also blackish; pterostigma pale yellow. About twenty cross veins in costal area; inner gradate series somewhat irregular in arrangement, containing six or seven veinlets; outer series runs almost parallel to the outer margin of the wing, and is made up of some nine or ten cross veins.

Hind wing narrow; veins mostly fuscous, but radius, media, cubitus and anal veins pale yellow; cross veins mostly blackish, but those in anal area of the wing pale yellow. Inner and outer gradate series each consists of about seven cross veins.

Abdomen yellowish, somewhat fuscous on ventral side; the male with a long subgenital plate, which is covered with fine pale yellow hairs, and is rather triangular in shape when seen from below; dorsal appendage short, furnished with numerous long hairs.

Length of body, 10 mm.; of antenna, 13 mm.; of fore wing, 13 mm.; of hind wing, 11 mm.

The type is a single male specimen captured by the author at Hakone, on July 29, 1914.

Chrysopa yamamuræ n. sp.

Head yellowish, somewhat raised on vertex; a distinct black spot on each cheek; palpi yellowish; antennae yellow, more or less suffused with fuscous beyond middle.

Prothorax pale yellow above, suffused with fuscous or darkish on each side, with a minute blackish spot on anterior end of each lateral margin. The rest of thorax and abdomen yellowish, with a pale white median stripe above. Legs yellowish, with pale hairs; claws piceous black.

Wings hyaline. Longitudinal veins in fore wing entirely greenish yellow; costal, radial, cubital and anal cross veins and all of gradate veinlets blackish; radial sector and its branches greenish yellow, but each is blackish at base; number of gradate veinlets in the inner series 5–7, in the outer series 6–8. Hind wing with venations mostly greenish yellow; costal cross veins black, one or two radial cross veins and greater part of gradate veinlets blackish.

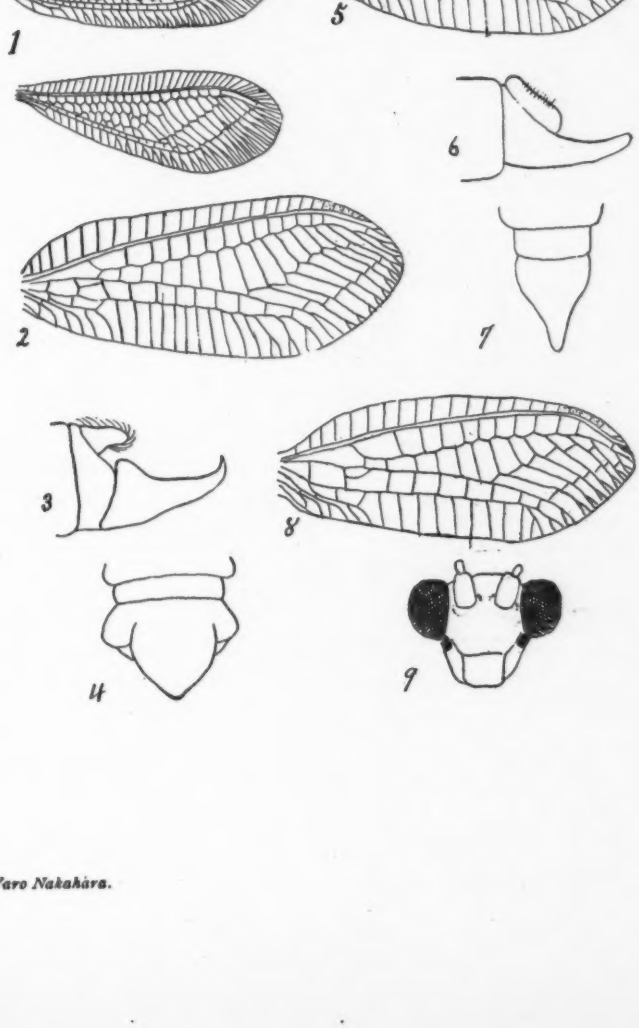
Length of body, 8–10 mm.; of fore wing, 12–14 mm.; of hind wing, 10–12 mm.

Three male and two female specimens captured by Mr. S. Yamamura at Gifu are in my collection.

At first sight one may take the species for *Chrysopa alba*, but *yamamuræ* is easily recognized by the black spot on each cheek.

EXPLANATION OF PLATE VIII.

Fig. 1. Wings of *Apochrysa minomoana* n. sp.
Fig. 2. Fore wing of *Parachrysa olivacea* (Gerst.).
Fig. 3. Apex of abdomen of same ♂ (from side).
Fig. 4. Same (from below).
Fig. 5. Fore wing of *Chrysocerca japonica* n. sp.
Fig. 6. Apex of abdomen of same ♂ (from side).
Fig. 7. Same (from below).
Fig. 8. Fore wing of *Chrysopa yamamuræ* n. sp.
Fig. 9. Face of *Chrysopa yamamuræ*.



Waro Nakahara.

GEOGRAPHIC DISTRIBUTION OF NEUROPTEROID INSECTS, WITH AN ANALYSIS OF THE AMERICAN INSECT FAUNA.

By NATHAN BANKS.

It is usual in general works on distribution to consider insects as widely dispersed by winds, and sea-currents, and therefore of little use in geographic studies. But every entomologist knows that the great majority of insects are more circumscribed in distribution than many of the higher animals. There are many insects of as wide distribution as the human species, but for each of these there are thousands that are confined to a very restricted range. Of our 15,000 known species of beetles only 500 or 600 are also known from Europe. Many of these belong to a few families of particularly northern distribution, many are accidental captures, and many have been introduced by commerce. Insects, when properly investigated, are just as useful in studying distribution as any other animals.

It has been remarked that there are two principal viewpoints from which to study geographic distribution. One is to consider what animals inhabit each country, and from these facts divide the world into a series of regions, subregions, etc. This, the static method, is, to my mind, extremely useful, and has been utilized by many, and may be followed to much advantage. It presents the facts that are to be accounted for by our theories. The other viewpoint is how the fauna of a country came to be what it is; an attempted explanation of its various elements. This, the dynamic study of distribution, depends largely upon geology, palæontology, and upon philosophic considerations regarding the origin, habits, and means of dispersal of the various groups of animals. In reality these two viewpoints are the beginning and end of the same thing.

From this dynamic viewpoint one sees that the insect fauna of a country, as the United States for example, is partly due to what it has inherited from previous land-masses in this vicinity, partly to what has migrated to it in ancient times, and partly to what has reached it since the continents have existed in their present form.

An insect that belongs to a country through inheritance, and one that it obtains through migration or dispersal, each may spread over that country and exist side by side; or each may be restricted to a very narrow range. The many cases of insect introduction in historic times show that great numbers of insects not now occurring here, could live and thrive with us.

The various orders, families, and genera of insects did not originate at the same time and place. The place of origin, and the changes that have elapsed since their origin have a definite bearing on their distribution today. Most divergent views of the relationship of certain faunas are often expressed by students who consider different groups. For example the Panorpid fauna of the United States would show that the Eastern United States is closely related to Europe, while the Raphidiidæ would show that it is the Western United States that is related to Europe. Again the large and rather recent family of butterflies, Heliconidæ, are only neotropic; while the ancient, small, family Sialidæ are of world-wide occurrence. The explanation must be in the different time and place of origin of these groups, and the continental changes that have aided or barred their dispersal.

From a study of mammals and birds zoologists divide up the world into several zoological realms, whose outlines agree fairly well with those of the continents; thus we have an African, Australian, South American, Malayan, Indian, and Holarctic realms; the latter for Europe and North America. With insects this is not so. Several, probably all, of the continents possess elements showing relationship to other regions, derivatives of a fauna more fully developed elsewhere, and indicating that insect distribution is much older than the present form of the continents. Thus the Nearctic part of the Holarctic realm is not a unit, but a commingling of natives and immigrants from times long before there were any mammals.

New Zealand has been included in the Australian realm, yet the insect fauna of New Zealand is more foreign to Australia than to America. Moreover, Australia presents at least two very different series of insects, one similar to that of Europe or at least to the fossil insects of Europe, and the other a series of peculiar, often primitive forms entirely unlike the European insects.

Since the main orders of insects have existed on this earth the gross outlines of continents have changed several times, and between these changes there were migrations and dispersals, just as there is today. So that today each continent has insects which by their structure and origin are isolated from the other insects around them and find their relations only to insects of distant countries.

The striking cases of discontinuous distribution have to me a most significant importance; I hardly think that their value has ever been sufficiently appreciated by the student of geographic distribution.

A few years ago I stood in an isolated valley in Western North Carolina. About me were flying several species of *Panorpa* and a *Bittacus*, Panorpids which are widely distributed in the Eastern United States, not one of which occurs in the Western States. Yet right with these Panorpids was another, a species of *Panorpodes*, a genus whose only other known habitat is Oregon and Japan. In that same valley are many spiders, nearly all of which are common over much of the Eastern United States, but yet there, and in several nearby places in the Southern Appalachians, is a curious spider, *Hypochilus*. Where else does it occur? In Colorado, and a closely allied genus in North China, and one in New Zealand. *Hypochilus*, and its related genera are the only known members of what is structurally the most isolated family of spiders. *Panorpodes* is also a very distinct genus and less specialized than the other Panorpid genera around it.

These two cases are but samples of a long list of insects (and also plants) that show a relationship of our Alleghanies with the Northwest, and with Japan and North China. How did it happen? I doubt if you can find a single genus of insects which is now known only from the Southern Appalachians and say from Eastern Brazil, or West Africa; regions no more distant than Japan. Why are there not such cases?

Consider another series of cases. In Eastern South America, in Argentine, and parts of the Andean region there are several species of a genus of handsome antlion flies, *Dimares*. It is structurally very unlike anything else in South America. Yet in South Africa, in Arabia, in Ceylon are species of another genus *Echthromyrmex*, so similar to *Dimares*, that one is loathe

to separate them. Both have a venational peculiarity unknown in all other Myrmeleonidæ. Another genus, *Creagris*, common in Africa and India, even to Australia, is represented in South America by *Dimarella*, which possesses the same structural peculiarities, otherwise unknown in the family. One of the most distinct genera of the Chrysopidæ is *Apochrysa*. It occurs in Australia, Insulinde, Ceylon, Africa and Eastern South America up into Central America. A distinct genus of caddice flies, *Leptonema*, common in South America, occurs elsewhere only in Africa and Ceylon. The Oestropsychid caddice flies, of which there are five genera, have a similar distribution, one genus in Insulinde, three both Indian and African, and one Brazilian. The restricted genus *Embia*, abundant in Africa, has several species in Brazil. The peculiar Oligoneurine mayflies are known from Southern Europe, Africa, Northern South America, Central America and West Indies. These instances from the Neuropteroid insects can be duplicated in other orders of insects. What does this relation between South America and parts of Africa and India mean?

Consider a third series of cases. Again and again entomologists have called attention to the fact that many structurally isolated Australian and New Zealand insects find their nearest counterpart in certain Chilian forms. This is as noticeable in the Neuropteroid insects as in other orders. The curious Australian Perlid genus, *Eusthenia*, is closely related (as far as existant forms are concerned) only to the Chilian genus, *Diamphipnoa*. *Stenosmylus* occurs only in Australia, New Zealand, and Chili; *Psilochorema* only in Chili and New Zealand; the Chilian Mantispid, *Drepanicus*, is most closely related to the Australian genus, *Ditaxis*. The termite, *Porotermes*, is from Chili, Australia, Tasmania, and South Africa. There surely must be a reason for this distribution.

There are still other series of cases of widely discontinuous distribution. One is the similarity between certain insects of Patagonia, the Straits, Falkland Islands, etc., and insects of Europe and North America. The Limnephilid caddice flies are almost wholly Holarctic in distribution, and constitute a large share of our Trichopterous fauna. One or two reach North Africa and Mexico. In the tropics there are none, but in this Patagonian region they reappear in genera the same or closely

similar to our own. The same can be said of other insects; in Carabidæ *Pycnochila* and *Omalium* are such examples. Mabille reporting on Lepidoptera from Terra del Fuego and Cape Horn, remarks on the likeness of that fauna to the European and North American. Elwes has noted the same thing in butterflies.

Another series of cases represent the relationship of the insects of the Madeira and Canary Islands to those of the Mediterranean region. This has been extensively studied by Wollaston and Murray for the Coleoptera, and the Neuroptera, though not so fully known from the islands, tell the same story.

A series of cases, familiar to us, of discontinuous distribution, are those due to the advance and subsequent retreat of the ice-cap. The cases of butterflies and other insects and spiders stranded on the tops of various mountains are well known; and it should be noted that living with these stranded insects are many others that occur all over the neighboring country. The Holarctic insect fauna includes hundreds of cases of discontinuous distribution; species the same or closely allied in North America and Europe. These are usually cases of divergent evolution, since in nearly all cases a close comparison shows that they differ slightly in structure, or color, or habits.

After one is familiar with the appearance of the insects of the United States and begins to examine exotic forms, he naturally compares them with those of this country, or of Europe, whose fauna is well-known.

The Neuropteroid insects that I have seen from South America frequently fall into our genera or are closely related thereto. Certain Chilian forms, and a few others like *Apochrysa*, *Dimares*, etc., look foreign. When I examine the Neuroptera of Japan and India the same idea appeals to me—how many are closely similar to our own. Here and there, as *Perissoneura* of Japan, and *Palpares* in India, are foreign forms. When I consider the Australian Neuropteroids I see also a number that are strikingly like those of the United States. Even frail and isolated genera, as example *Sisyra*, occur in closely allied species right through from United States, Europe, India, Japan, Insulinde, and to Australia. But with these familiar insects are many that are widely different from our own.

This foreign element that I notice in South America, in India, in Australia is the typical African Neuropteroid fauna.

When I examine the Neuropteroid insects from tropical and South Africa and Madagascar, I see that a large part are strange to me. That where genera are the same, they are usually worldwide, and that many of our typical forms are wholly unrepresented in Africa.

The points wherein Australia differs from the United States are in many cases just the points wherein Australia agrees with Africa and Ceylon.

For example, *Psychopsis*, a remarkable Hemerobiid that forms a tribe or subfamily by itself occurs in several species in Australia, East Africa and India. *Ankylopterus*, *Protoplectron*, *Lysmus*, *Creagris*, *Nesoleon*, *Atalophlebia*, *Notanitolica*, *Dipseudopsis Periclystus*, *Suhpalasca*, etc., all show the relation of Africa, India, Malasia, and Australia. Various other genera connect Africa and India as *Palpares*, and *Tomatares*. Similar striking insects in other orders indicate the same relationship.

There is, therefore, broadly speaking but three types of insect fauna, as already noted by Murray. One, the Microtypal, includes many of the insects of Europe and North America, and Northern Asia, a considerable element in Andean America, many in India and Insulinde, and New Zealand, a district representation in Australia, but very poorly developed in Africa.

Another fauna is the African or Gondwandan; it embraces many of the forms most peculiar to us. Its present home is Africa, but strong in Australia and almost as strong in Insulinde and Ceylon, plainly present in India, and noticeable in South America through various isolated genera. We may mention some of the peculiarities of this Gondwandan fauna in Neuropteroids. There are no Limnephilid, nor Rhyacophilid caddiceflies, no *Raphidia*, no *Panorpa*, no *Sialis*, in fact many of our common genera are there represented by different genera.

And third, is the Brazilian fauna, a more recent development; this does not appear so distinct in the Neuroptera as in the Lepidoptera, but we may cite *Allochrysa Callibœtis*, *Haploglenius*, *Ululodes* (and allied genera), *Trichoscelis*, *Campsurus*, *Euthyplocia*, *Thrysophorus*, *Blepharopus*, *Phylloicus*, *Marilia*.

It is so customary to consider New Zealand as part of the Australian realm that I desire to express as strongly as possible that as far as their insect fauna is concerned Australia and New Zealand are much more related to other parts of the world than

to each other. Sharp says "The Coleopterous fauna of New Zealand seems to have most affinity with that of Chili and Patagonia, and but little with that of the Australian fauna." Meyrick holds that for the Lepidoptera "New Zealand is utterly different from Australia." The Neuroptera show the same differences.

New Zealand lacks all the peculiar, primitive or synthetic Neuroptera such as *Ithone*, *Eusthenia*, *Nymphes*, *Stilbopteryx*, *Mastotermes*, *Plectrotarsus*, etc., that occur in Australia. There are no Ascalaphidæ in New Zealand, many in Australia, no Mantispidæ in New Zealand, many in Australia, only one (an separate genus) of Myrmeleons in New Zealand, many in Australia. Among the true Neuroptera *Stenosmylus* occurs in Australia and New Zealand, but also in Chili. New Zealand is remarkable for its Trichopterous fauna. At least 15 genera are now known from there, some so peculiar they have not been placed in the known subfamilies. Six are not known elsewhere in the world. One (the famous marine caddice fly) occurs elsewhere only in Australia. Three others occur also in Australia, but also in other parts of the world, two of them in South America. Five occur in various parts of the world, not in Australia, all in South America.

In the Mayflies New Zealand has at least 6 genera, three peculiar to the islands, two in Australia, one of which is also elsewhere, and one also in North America. In fact, there are no two regions of the world that are geographically so close and entomologically so remote as Australia and New Zealand.

From the above considerations I consider it certain that since the origin of the various orders of insects the continental land-masses have changed entirely. That for a very long period there were two principal continents of very different shape from any that we have at present, and that on one was developed the microtypal fauna, and on the other the Gonwandan; the Brazilian fauna being a more recent development. That the continental changes have favored or prevented dispersal, and these continental changes are the real causes of the peculiarities of faunas, and that proximity has little to do with distribution.

These series of cases of discontinuous distribution are positive evidence of land connections, now broken, of avenues of dispersal, now closed. The surprises of distribution are due not

only to these land connections, but to the varying places of origin of the various families and genera. Of the insects in any country, some are endemic, some ancient migrants, some more recent migrants.

Our western Raphidiid fauna, and absence of Panorpid fauna could be explained in two ways. The Raphidiidæ may have arisen there and migrated to Asia during a land connection, or else if it came from Asia the genus Panorpa was not as abundant in Asia as at the present time.

It will be seen from the foregoing that I consider the insect fauna of the United States to be composed of several elements. I believe there are at least five that can easily be distinguished.

1. Genera which are relicts of a very ancient fauna when land masses were of a different conformation from now. These genera are isolated in our fauna and mostly examples of discontinuous distribution.

One of these series includes the *Panorpodes*, the *Hypochilus*, *Lachnocrepis*, *Pristodactyla*, *Tachopteryx*, *Hagenius*, *Tmesiphorus*, *Midea* (section of *Anthocharis*), *Cryptocercus*, of the Alleghanian fauna, and doubtlessmany other forms showing relation of Californian and northwest with Europe or Siberia and Japan. Such are *Raphidia* and *Megalomus* in Neuroptera. *Paraplinthus* and *Necrophilus* are apparently also in this series, and probably *Amphizoa* and *Cephaloon*, perhaps *Rhinomacer*.

In Southern California there is a series of isolated genera which indicate relationship to a very ancient fauna, perhaps connected to the islands of the South Seas. Such are *Dinapate*, *Distaxia*, *Schizopus* (Coleopt.), *Oliarces* (Neur.), *Hubbardia* (Arachn.), *Timena* (Orth.), probably Apioceridæ (Dipt.), and the true Thynnidæ (Hym.), also belong to this group, which stands widely apart from the other insects around it.

In this section we might include any descendants from our Palæozoic insects; I doubt if it is possible to trace any such genera, but our curious *Merope tuber* may be such a form. The Sialidæ may have arisen within our territory as descendants from Palæozoic forms, but from their present distribution one would suspect Southeastern Asia as their starting place. Our mayflies are probably later migrations; *Pteronarcys* in Perlidæ may be a derivative of that ancient fauna, but I doubt it; our cockroach fauna is also probably due to later migrations.

2. Genera representing relicts of probably an ancient invasion from South America, possibly through the West Indies, and after South America had been connected to Africa or to a Pacific continent. These genera are isolated systematically in our fauna, forms that look out of place in our insects, and usually unrepresented in Europe either recent or fossil, at least northern Europe. Such in the Neuroptera are *Dilar, Amphientomum, Neoperla, Leptocella, Ganonema.*

In Coleoptera, *Cupes, Ischalia,* our *Lymexylon, Othnius, Passalus, Pseudomorphus, Brenthus.*

In Hemiptera *Henicocephalus, Cylapus, Fulvius, Isometopus,* probably *Belostoma, Oncerotrachelus, Ceratocombidæ, Rhagovelia.*

In Hymenoptera, *Rhinopsis, Pelecinus, Leucospis, Stizus, Pristocera.*

In Diptera, *Phlebotomus, Nemistrinidæ, Mydas, Calobata, Sphyracephala, Euxesta, Pyrgota, Blepharoceridæ, Stylogaster, Systropus.*

In Lepidoptera *Feneseca, Thyris, Stenomma, Hemerophilidæ, Halesidota.*

In Orthoptera, *Camptonotus.*

It will at once be noted that this element is almost wholly Eastern, and is the element that distinguishes our Eastern States both from the Western States and from Middle and Northern Europe, in fact a tropical element still present with us, and most noticeable in mid-summer.

3. Genera originating in this country from an insect fauna of which 1 and 2 are the relicts. These are genera confined to the United States but whose affinities are rather with South American or Asian insects than with European. I consider that this fauna had a long period of quiet development and became very extensive. The Miocene fossils perhaps represent this fauna.

In Neuroptera, *Meleoma, Bætisca, Polypsocus, Paraperla, Neophylax, Heteroplectron, Nannothemis,* etc.

In Coleoptera, *Sandalus,* and many other genera.

In Hemiptera—*Sinea, Corythuca, Araphe, Corynocoris, Telamona, Cyrtolobus.*

In Hymenoptera, *Lyroda, Grotea, Labena, Ceratogastra.*

In Diptera, *Eclimus, Pelastoneurus, Bittacomorpha, Eutreta, Acrotoxa, Pseudotephritis, Idana.*

In Lepidoptera, *Psychomorpha*, *Acoloithus*, our Blastobasidæ.

In Orthoptera, *Stenopelmatus*, *Ceuthophilus*, *Hippiscus*.

In this fauna there was apparently no Cicadidæ, no Mantidæ, nor Mantispidæ, no Mutillidæ, no Ascalaphidæ, no Myrmeleonidæ, no Emesidæ, and few forms of a number of families, now fairly well represented here. These came in later from the South.

4. Genera (and derivative genera) representing the holarctic fauna shoved down by the advance of the ice-sheet, and left well scattered by the retreat of the ice-cap. These are the forms that show the relationship of our insect fauna particularly that of the Eastern States (and British America) with the insects of Northern and Middle Europe. The bulk of many large families belongs to this section, which is most prominent in the spring.

In the Neuroptera, nearly all the Trichoptera, probably *Panorpa*, *Hemerobius*, *Chrysopa* in part, several genera of Odonata as *Sympetrum*, *Aeschna*, *Cordulia*.

In Coleoptera, much of the Carabidæ, Staphylinidæ, etc.

In Hemiptera, many Capsids, Lygæids, and *Corixa*, Jassidæ, Aradidæ, *Corizus*, *Salda*.

In Hymenoptera, many Tenthredinidæ, Ichneumonidæ, *Osmia*, *Bombus*, *Andrena*, *Crabro*.

In Diptera, many Muscidæ, Anthomyiidæ, Syrphidæ, and genera in nearly all families, as *Bombylius*, *Pipunculus*, *Syrphus*.

In Lepidoptera, many Noctuidæ, Geometridæ, and genera all through the order.

In Orthoptera, *Tettix*, *Gryllus*, *Decticus*, *Podisma*.

This element is recognized by all entomologists; possibly the lower borders of this Holarctic fauna was contiguous to the previous element, and represented by the Florissant fossils; but I am inclined to believe that these fossils show more relation to a Western fauna rather than to a northern one.

5. Genera representing a comparatively recent influx from the American Tropics, a migration still in progress. To this belong our Mantispidæ, much of Myrmeleonidæ, Ascalaphidæ, Mantidæ, Cicadidæ, Mutillidæ, Brenthidæ, much of the Reduviidæ and other Heteroptera, many genera as *Acordulecera*, *Pepsis*, *Allochrysa*, *Resthenia*, *Hæterinia*, *Callibætis*, the Ana-

phoridæ, *Megacilissa*, *Exomalopsis*, *Entechuia*, *Apiomerus*, *Conorhinus*, *Anasa*, *Zelus*, *Polybia*, *Schistocerca*, *Volucella*, *Schinia*.

I doubt not but there are other elements also in our fauna, but I think that these are the most noticeable, and sufficient to show that the Nearctic insect fauna is not a realm, but a conglomeration of several such realms.

The history of each insect is written in its structure. It is therefore possible to discover where each form arose and how it accomplished its distribution. This involves a study of the phylogeny of the genus or family, an investigation of its original home, and the causes that have aided or barred its dispersal; but the essential basis of all is the systematic study of the group.

SUGGESTIONS FOR TRACING RELATIONSHIPS OF INSECTS.

By NATHAN BANKS.

In studying any group, especially when one is trying to make a synoptic table, we become interested in the relationships or affinities and try to arrange the species or genera according to our ideas of their phylogeny. Yet, I fear in many cases we proceed without any clear idea of a basis for decision. It is evident that in different groups different methods may be necessary, but there are a few considerations which I think may apply to many cases.

Some authors try to put first those forms that possess primitive characters, or the greatest number of such characters. Others take certain synthetic forms which seem to show relationships in several directions as a starting point for the group.

Everyone has observed that in any large group, as an order, there is contradictory evidence as to what is the most primitive family or genus. In Coleoptera for example, certain genera have more free ventral segments than usual, other genera have ocelli, or traces of a median suture on the head, yet some of these will not have the five-jointed tarsi.

A case familiar to me is the Hydropsychid caddice-flies. Their ancestors were near the Rhyacophilidæ and had 3, 4, 4, spurs, ocelli present, and the female with two little appendages at tip of the body. We find in the Hydropsychids that some have ocelli, but do not have the 3, 4, 4 spurs, while others have the 3, 4, 4 spurs, but not the ocelli, and various genera have the primitive abdominal appendages.

In other words primitive characters are inherent in the descendants and may be developed in various parts of the descendant series, or, more properly, retained by varying lines of descendant series, so that taking any family of existent forms several arrangements are possible according to what primitive character is chosen as the criterion.

Genera differ from other genera by at least two sets of characters. One is the positive characters, the presence or absence of a structure, the other is in accrescent characters, or developing

tendencies. The positive characters are most useful in delimiting genera (and other groups) but because of their constancy of little value in tracing relationship. It is to these accrescent characters that we should look for phylogeny.

If several species of a genus A have spines on the vertex, and an allied genus also has spinose vertex, it is not likely that these spines in genus A will indicate relationship; but if in a series of genera with bare vertex, there is a genus in which spines are present, then the arrangement and size of these spines may indicate phylogeny. Take for example the spider genus *Tetragnatha;* it has a peculiar character in the enlarged, much-toothed mandibles; a study of the increased modification and armature of these mandibles will afford clues to relationship of the species. Formerly I and others have used variations in eye-position as group characters, but these same variations in eyes occur in allied genera and so may occur in various parts of *Tetragnatha* irrespective of phylogeny.

Therefore, to my mind the best way to get at the relationships of the species of a genus, or the genera of a family, is by tracing the development of some character peculiar to the series; an accrescent character, found in varying stages of development in the group, but not found in allied groups, particularly groups that may be considered ancestral to the group in question.

There are many prominent cases where, I believe, primitive characters have deceived systematists. For example, in spiders the cribellum and calamistrum are primitive characters, and occur in groups otherwise widely separated. Several arachnologists have insisted on grouping these forms together, thus producing a most heterogeneous assemblage, whereas if they would ignore these primitive characters, and study the accrescent development of some peculiar character of spiders they would reach a better knowledge of their phylogeny; the male palpi are just such a character.

Another case is the pronotum in Hymenoptera extending to the tegulæ; Ashmead put the social and fossorial wasps together on this account; the character occurs elsewhere in the Hymenoptera, and therefore cannot be depended upon to indicate affinity. In the Lepidoptera various systems have been based on the possession of some primitive character, thus the case-forming habit of larvæ, the jugum, mandibles, number of anal veins, etc.,

have served to unite groups otherwise discordant. A careful study of the proboscis, or the scales might serve to give clues to phylogeny.

In the Coleoptera, tarsal and antennal characters have been used yet mostly in vain, the elytra, a character peculiar to the group, should be investigated. If we consider groups as large or larger than families we notice that specialization has not proceeded along one definite line, but the line of specialization is continually changing, and often accompanied by other modifications. Each change in the line of specialization marks the limits of a group of greater or less extent; one structure having reached a certain stage marks time while other structures are modified.

The Mantispidæ have peculiar front legs, having reached a certain development this structure remains fairly stable, while other structures develop. The Limnephilidæ in the Trichoptera are an example of stability in venation; generic characters are largely to be found elsewhere, while in the Sericostomatidæ venation continues to vary and aid in defining genera.

In the Diptera the Muscidæ, Tachinidæ, Dexidæ and Sarcophagidæ were defined by bare or pilose antennæ, yet genera with pilose antennæ occur in various related families. An accrescent character of these groups appears to be the chaetotaxy, and this has been used to indicate a new classification of these families.

Structural and other characters may be roughly grouped into two sections, adaptive, that is those which have been influenced by environment and habits, and atavic, or those which are of no use to the insect, and persist because they are not in the way, and have a long history back of them. The adaptive characters are of use in small groups to indicate affinity, but soon break down when applied on a larger scale.

Thus two eyeless species occurring in the same caves may be closely related when belonging to one genus, but most such eyeless cave insects are not related. As a whole adaptive characters are of little use in tracing relationships. It is the atavic, or accompanying characters, not related to a life-habit, that are the best for indicating affinity. All insects have many points of structure or color that are of no use to them. Many of these

characters are variable, and one must endeavor to find by an examination of a long series of at least a few species what characters are constant.

Atavic characters usually exist unchanged through a long series, so they are of no use (or little use) in tracing affinity within a genus. They are of most use in indicating the relationships of genera and families, and especially where insects have acquired a number of striking adaptive characters, some of which may be those of convergence and tend to conceal the true affinities.

Other points might be brought out, but at present I desire to impress upon systematists that atavic characters should be sought in the broader fields of classification, while in many studies, particularly in genera, accrescent characters should be considered, while the use of primitive and of adaptive characters should be avoided, or used only in connection with the others.

LIFE HISTORY OF THELIA BIMACULATA FAB. (MEMBRACIDÆ).

W. D. FUNKHOUSER.
(Contribution from the Entomological Laboratory of Cornell University.)

Thelia bimaculata Fab., is one of the most common and widely distributed of the species of Membracidæ in eastern United States and is abundant on locust (*Robinia pseudacacia* L.) in the vicinity of Ithaca, N. Y., where the following study has been made. The life history of this insect has not hitherto been described and the only reference in literature to the immature form seems to be the short description and the excellent figure of the last nymphal stage by Matausch* in 1912. Although both adults and nymphs may be collected in large numbers throughout the summer, the efforts of several years of rather extensive field work on the local forms of the family failed to show any records of oviposition or traces of the eggs until it was noticed that early in the spring the nymphs appeared most abundant near the bases of the trees and seemed to be migrating upward on the trunk, which led to the natural conclusion that the eggs were laid near the ground. This surmise proved to be correct and upon removing the dead leaves and humus from around the bases of the trees, great numbers of nymphs with their attendants were exposed, and the bark, a few inches under the forest litter and just above the roots, was found to be punctured with egg-slits and full of eggs and emerging nymphs. This location for the egg-punctures is rather peculiar, since most of the species of Membracidæ common to this locality lay their eggs in the buds or in the younger twigs near the end of the branches.† After the eggs were discovered and the egg-laying habits observed, no difficulty was experienced in rearing the insects and in securing the rest of the life-history data.

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* Matausch, Ignaz Bull. American Museum Natural Hist. 1912. Vol. XXXI: 26, 333. Pl. 29, Fig. 7.

† Cf. Hodgkiss, H. E. The Apple and Pear Membracids. Geneva Agr. Exp. Sta. Tech. Bull. No. 17. 1910.
Riley, C. V. Proc. Ent. Soc. Wash. 1893. Vol. III: 88–92 p.
Marlatt, C. L. Insect Life. 1894. Vol. VII: 8–14 p.
Matausch, I. Observations on the Life History of Enchenopa binotata Say. Journ. N. Y. Ent. Soc. March, 1912. Vol. XX: No. 1. 58–67 p.

General Description.

This species of Membracidæ is one of the largest representatives of the family found in New York state. The male was originally described by Fabricius in 1794 and no doubt received its specific name from the gaudy yellow fascia on the thorax. The female is quite different in color from the male, being of a sober uniform gray with occasional irregular brownish markings. *Thelia bimaculata* is the type of Amyot and Serville's old genus *Thelia* (1843) and is one of the few remaining species now left in that genus.

The species may be at once recognized by the porrect pronotal horn, the longitudinal ridges of the prothorax, the sharp posterior process and the yellow stripes of the male.

Habits.

Of all the insects which inhabit the locust none are more interesting or more easily observed than this large and handsome species of membracid. Locally they may be found in remarkable numbers from early spring until late autumn, and with their nymphs and constantly attending ants provide a most profitable source of study. They seem to prefer the smaller trees and are most abundant in rather open growths where the trees are young and not over twenty feet in height, and here they choose the lower branches and the trunk for their resting places. They are seldom found more than fifteen feet above the ground. Like most membracids they enjoy the sun and the most favorable collecting places are the trees in the open fields, along the roadsides, and at the edges of timber. They are seldom, if ever, seen in shady woods. The adults have the interesting habit of resting on the larger branches and on the trunk in rows of from twenty to forty individuals, ranged so close together that their bodies are almost touching, and almost invariably with the heads pointing towards the base of the branch, or pointing downward if they are on the trunk. Whether this characteristic attitude is assumed in order to increase their resemblance to the thorns and irregularities of growth of their host, would be a matter of conjecture. An idea of the number of individuals which may thus be found may be given by the fact that one field note (July 22, 1911) records the taking of 280 adults and over 200 nymphs at one time from one small tree.

The species is not active, although the insects fly well for short distances with a distinct buzzing flight, and they may usually be picked up with the fingers without difficulty. The males are more active than the females and more easily disturbed. Migration is evidently slow, as it often happens that one tree may be covered with individuals while another in close proximity is unmolested. In this locality, under ordinary conditions, both sexes appear in nearly equal numbers until about the middle of August, after which time the males become scarcer and by the first of October have practically disappeared, although the females remain abundant until late in November. Females have been collected, in fact, some time after the first few snows have fallen, but there is no evidence to show that any of the adults winter over.

The nymphs are usually found on the trunk near the ground, tightly flattened against the tree in the crevices of the bark, a position which makes their protective resemblance truly remarkable, and where the gray color and spiny dorsum is conducive to a most effective concealment. The larger individuals migrate upward and when seen on the branches are found pressed closely to the bark in the crotch of a twig or the axil of a leaf, where they tend to escape any but the most careful search. They are, however, attended by ants in large numbers, and these vigilant attendants betray to the collector of the nymphs the object of his search. The anal tubes of the immature insects are capable of great evagination and from these tubes issues in bubbles the liquid which the ants seek. This liquid appears to be secreted more abundantly when the ant strokes the nymph with its antennæ. When picked up in the fingers the nymphs at once eject some of this fluid, sometimes in considerable quantities. The ants attend the adults as well as the nymphs but only the nymphal forms have been observed to give off liquid in the manner described. The ants do not hesitate to protect their charges, and bite viciously the fingers of the collector who seeks to remove the nymphs from the tree.

Mating and Oviposition.

Under natural seasonal conditions mating begins in the field about the first week in July. The position assumed in this process is the one not unusual in Hemiptera, with the caudal extremities together and the heads in opposite directions. The

individuals are very sluggish at this time and seldom move unless disturbed. The time taken in the field for the process is generally about twenty minutes, but one pair in the laboratory remained *in cop* for almost an hour. Mating continues throughout the summer, the largest number of cases being noted during the last week in August. The last date on which this process has been observed in the field was November 6th.

In oviposition the female descends to the base of the tree, with the head pointing downward, and makes a narrow longitudinal slit about seven millimeters long in which the eggs are deposited. In very young stems the egg-slit sometimes pierces the wood but in most cases the ovipositor is deflected on striking the wood and slips to one side, the eggs being laid in the cambium between the bark and xylem. The slit is very narrow and hardly noticeable but the tips of the eggs may be seen protruding very slightly out of the bark when the process is completed (Fig. 3.) The eggs are about 2½ mm. long, white and club-shaped (Fig. 1). They are laid in a palmate formation (Fig. 2) recalling the egg-mass of *Stictocephala inermis* Fab.,* but much larger. The bases of the eggs are about 5 mm. apart and the apices compressed closely together. The number of eggs varies from three to six in a slit, the latter number being most common. The process occupies about forty minutes, after which the insect usually moves upward and slightly around the stem and repeats the process. One female has been known to make three such slits in succession, but as egg-laying is usually observed in the late afternoon it is difficult to keep field records on this score and the average number of egg-masses laid by one female at one time may be larger. Dissection shows the average number of eggs in the abdomen of the female to be twenty-eight.

Emergence and Development of Nymphs.

The first numphs begin to appear in late May and early June. Field records made on May 30, 1911, June 1, 1912, June 2, 1913, and June 1, 1914, show that the early stages were collected on these dates. About two days before hatching, the tips of the eggs begin to crack and just before the nymphs emerge, break open at the top and usually split some distance down the side.

*Agr. Exp. Sta. Tech. Bull. 17. Geneva, 1910. Pl. 2, Fig. 5.

There are five instars and each may be easily recognized. In the first (Fig. 4) the insect is almost white and the dorsum is armed with branched spines as in the case of the nymphs of the subfamily *Ceresini*. The beak is very long, reaching almost to the tip of the abdomen. In the second instar (Fig. 5) the nymph is dark colored, the thoracic spines have almost disappeared, the abdominal spines are much shorter and three-branched and the beak still very long. The third instar (Fig. 6) shows no thoracic spines but a swelling which precedes the pronotal horn, the meso- and metathoracic segments are slightly lengthened at their lateral margins and the abdominal spines are simple and not branched. In the fourth instar (Fig. 7) the pronotal swelling has become lengthened and porrect and the wing-pads are apparent, while the abdomen is marked with dark spots and the beak is shorter. The fifth and last instar (Fig. 8) presents a greatly developed pronotum which now covers the mesonotum, the wing-pads are fully developed and the legs are characteristically mottled with brown.

The time occupied in this process appears to be subject to some variation but whether this is due to seasonal or weather conditions it has not been possible to determine. It has been noticed that the nymphs which appear in the early summer require a slightly shorter time between the periods of molting than those which emerge in the fall. It has also been observed that in some cases the males appear to require a longer time in each nymphal stage than do the females. The first molt usually occurs about a week after hatching; the second five days later; the third instar lasts six days; the fourth instar six days, and the last, which is subject to the most variation, from eight to fifteen days. Thus the total period from egg to adult is approximately one month.

Ecdysis.

The splitting of the integument first appears on the dorsal part of the head. It then continues down the median dorsal line but seldom extends farther than the sixth abdominal segment. The head is released slowly but the thorax quickly follows and the integument sometimes breaks around the coxæ and femora leaving parts of the old skin attached to the legs for some time after the ecdysis is completed. In fact, this insect often leaves an imperfect exuviæ, and forms are commonly found with rem-

nants of the old integument still clinging to the legs and abdomen. The abdomen is removed slowly, here again, especially in the case of the female, small pieces of old skin sometimes remaining attached to the caudal extremity to be sluffed off later. The process is a comparatively rapid one, usually occupying about twelve minutes, while in one case observed in the laboratory (in the last molt) the time from the first splitting of the skin over the head to the complete emergence of the insect lasted only five minutes.

The recently emerged adults are almost white, the abdomen gray or greenish, and the whole body very soft. The thorax hardens rapidly and the normal color is completely apparent at the end of six hours. At first the colors are quite brilliant but become duller in a few days. The newly molted adults are very active and fly in a surprisingly short time but during the first few hours of their adult life the pronotal horn is likely to be injured on account of its soft condition, and if crushed or twisted will harden permanently in that position.

The old nymphal skins do not remain attached to the host but drop to the ground as soon as the ecdysis is complete. Consequently the cast skins are not seen on the trees as they are in the case of most of our other forms of Membracidæ.

Feeding.

Although careful field notes have been kept on this species for several years, and a very large number of individuals have been observed under natural conditions, surprisingly few actual instances of feeding have been noted. When recorded, it has always been in the early morning, and the insects have been, not on the more succulent twigs as might be expected, but on the second or third year's growth, with their beaks in the crevices of the bark. In the laboratory the nymphs fed on the young stems but the feeding periods were very short and they seldom moved about on the plant. No records were made of the nymphs feeding in the field. It may be noted that both while feeding and while molting the nymphs are constantly attended by swarms of ants which seem in no way to disturb the membracids and it has even been suggested by Miss Branch* that the ants are necessary factors in the life of an individual

* Branch, Hazel E. The Kansas University Bulletin. July, 1913. Vol. VIII: No. 3., p. 84.

membracid. The experience of that author, however, in rearing the nymphs of *Entylia sinuata*, in which species the molting was not successfully accomplished in the laboratory without the presence of ants, has not been experienced in the rearing of *Thelia bimaculata*, since this latter insect has molted repeatedly while in the cages in the insectary without the attendance of ants. The feeding of this membracid, likewise, has not seemed to be affected in the least by the absence or presence of these usual attendants.

Hosts.

Robinia pseudacacia L. seems to be the only host supporting *Thelia bimaculata* in this locality. Specimens have never been taken on any other tree although in general collecting for Membracidæ practically all of the local flora has been examined. Likewise, no evidences of eggs or nymphs have ever been found except on this one host. Neither have specimens of this species been collected in the grass or weeds or by sweeping and it seems evident that the entire life cycle of the insect is spent on the locust. As has been stated, the migration of this form seems to be limited and the insects appear year after year in a given group of trees while others nearby are not infested.

Enemies.

Parasitism is common in the eggs but none of the parasites have been identified in the course of this study. Many eggs fail to mature and are found to be punctured and blackened. The bodies of both nymphs and adults, also, often contain larvæ—apparently hymenopterous—but none of these have thus far been successfully reared although several attempts have been made to work out this phase of the subject. Matausch has recorded parasitism in this species† which destroyed the sexual organs but was not able to rear the parasites.

The larger Asilids occasionally carry off a membracid and in one instance a toad was found at the foot of a tree busily engaged in trying to secure the nymphs. In this case the operation seemed to be fraught with some difficulties on account of the tenacity with which the membracids held to their host and on account of their sheltered position in the cracks of the bark,

† Matausch, Ignaz. The effects of parasitic castration in Membracidæ. Jour. N. Y. Ent. Soc., Sept., 1911. Vol. XIX: No. 3. 194–196 p.

and they would doubtless have escaped unnoticed had it not been for the movements of the large ants running briskly about them. Birds apparently avoid the insect. No case of their being eaten by birds has been observed in the field, and several handfuls thrown to birds in captivity were refused, although one or two individuals were picked up, only to be dropped again. Evidently the strong pronotal horn and the sharp posterior process (the latter being sharp and hard enough to pierce the skin if the adult insect is suddenly seized) and the hard prothorax are sufficient protection from bird enemies. The bodies of these insects are occasionally infested by a small red mite, and not infrequently a membracid is found in a spider's web.

Attendance By Ants.

The attendance by ants on various species of Membracidæ has often been recorded. Interesting notes have been published on this subject by Mrs. Rice[1], Miss Branch[2], Belt[3], Green[4], and Lamborn[5], and attention called to the fact by other authors. In the case of *Thelia bimaculata* this is a most noticeable and interesting feature of their life-history. The species of ants which have been found attending both nymphs and adults have been very kindly determined by Professor W. M. Wheeler as follows: *Formica obscuriventris* Mayr, *Formica exsectoides* Forel, *Camponotus pennsylvanicus* DeGeer, *Crematogaster lineolata* Say and *Prenolepis imparis* Say.

Economic Importance.

Thelia bimaculata can hardly be considered as an insect of economic importance in so far as any damage to the tree caused by its presence is concerned. The amount of sap consumed is apparently very small and the method of egg-laying has practically no injurious effect on the host. The fact that the egg-slits are very narrow and placed longitudinally, makes it possible for the bark to quickly heal over the wound and the scars have

[1]Rice, Mrs. M. E. Insect Life. 1893. Vol. V: No. 4. 243–245 p.

[2]Branch, Hazel E. Morphology and Biology of the Membracidæ of Kansas. Kans. Univ. Bull. 1913. Vol. VIII: No. 3. p. 84.

[3]Belt, T. Honey exuding Membracidæ attended by ants. Naturalist in Nicaragua. 1874.

[4]Green, E. E. Note on the attractive properties of certain larval Hemiptera. Ent. Month. Mag. Aug. 1900. Vol. XXXVII: p. 185.

[5]Lamborn, W. A. Ants and Membracidæ. Trans. Lond. Ent. Soc. 1913. 494–498. p.

usually disappeared after the second season. No trace has been found of other insects or of fungus in the openings thus made, and since the ovipositor of the insect seldom penetrates the wood there is no trace of the incision below the bark. A careful comparison of trees in the field has led to the conclusion that those on which the membracids were numerous were in no way less sturdy than those on which no membracids were found.

Technical Descriptions.

Egg:

Measurements: Average length 2.6 mm.; average greatest width .6 mm.

Club-shaped. Smooth, without sculpturing. Translucent white with pointed end opaque white. Neck gradually acute. Chorion vitreous. Cap comparatively large, somewhat wrinkled. Micropylar apparatus opaque and white.

First instar:

Measurements: Length 1.8 mm.; maximum width .2 mm.

White, with brown head and brown dorsal spots; dorsal surface decorated with prominent bristles.

Head broad, flat, brown, covered with long bristles; constriction between head and thorax deep; eyes prominent, centers blood-red; antennæ colorless, well developed; clypeus white; beak white and extending almost to tip of abdomen; ferruginous maxillary and mandibular setæ visible. Prothorax prominent, brown, tuft of three paired bristles on median dorsal line, one pair of very fine bristles anterior to this tuft and a single bristle on each side below it. Mesothorax white with brown lateral patch on each side near dorsum, one heavy branched bristle on each side median dorsal line with fine lateral bristle below it. Metathorax white, four fine unbranched dorsal bristles. Abdomen with eight visible segments, brown above, white below, fifth and sixth segments white throughout, seventh and eighth segments brown above and white below, each of first six abdominal segments bearing above a pair of heavy branched spines suddenly acuminate in a fine bristle and two rows of fine lateral hairs, seventh and eighth segments with a pair of fine unbranched bristles on each side dorsal line, underside of abdomen white and sparsely pilose, anal tube protruding. Legs and feet entirely white, femora and tibiæ hairy. The above description from a specimen killed and described immediately on its emergence from the egg.

Second instar:

Measurements: Length 2–2.8 mm.; maximum width 1 mm.

Entirely light chocolate brown except undersurface of abdomen which is white; body very finely punctate with white.

Head finely pilose; dorso-cephalic part produced into two tuberosities; beak heavy and extending almost to extremity of abdomen.

Prothorax brown with two pairs of short blunt bristles. Meso- and metathorax each uniform brown with one pair of obsolete bristles on median dorsal line. Abdomen brown, posterior margins of segments darker; eight segments distinct, first six pairs bearing double row of blunt spines at dorsal line, each spine with short lateral bristles and ending in a fine hair, last two segments faintly bristled; anal tube prominent. Legs brown, somewhat lighter at joints.

Third instar:

Measurements: Length 3–5 mm.; maximum width 2–2.5 mm.

Gray-brown mottled with dark brown; undersurface of abdomen lighter. Body wider and flatter in proportion than in preceding instars; widest in abdominal region. Pronotal horn beginning to appear on prothorax and lateral margins of meso- and metathorax beginning to lengthen to form wing-pads.

Head wide, frontal tubercles prominent, front of head dark in color; eyes brown, facets distinct; ocelli visible; clypeus set off by distinct suture; beak extending to a point half-way between hind coxæ and apex of abdomen. Prothorax with prominent tuberosity on median dorsal line; entire dorsal surface of prothorax swollen. Mesothorax and metathorax almost smooth above; lateral margins of each of these segments extended in blunt points. Each abdominal segment bearing double row of short, sharp spines above; two parallel rows of dark spots on each side of abdomen in about the position in which the lateral hairs appeared in the first instar; anal tube prominent and black. Legs mottled brown; femora almost black; tibiæ lighter at extremities; tarsi flavous.

Fourth instar:

Measurements: Length 5–7.5 mm.; maximum width 2.5–3 mm.

Body robust; abdomen heavy; color light mottled gray. Pronotal process becoming porrect; prothorax overlapping mesothorax. Wing-pads well developed.

Head decidedly prone; frontal tuberosities pointing directly forward; eyes light brown; ocelli prominent; clypeus well defined; beak reaching just beyond posterior coxæ. Prothorax well developed; anterior process becoming porrect; posterior margin of pronotum beginning to overlap mesonotum. Mesothorax and metathorax almost smooth above; wing-pads well formed and prominent, covering one-third of second abdominal segment at lateral margin. Abdomen very light in color with longitudinal brown fascia above, almost white below; spiracles very distinct; anal tube darker than the rest of the abdomen and often much distended; first two abdominal segments almost smooth above, next five bearing short, thickened spines. Legs and feet mottled brown, sparingly spined and pilose; femora hairy and club-shaped; tibiæ somewhat flattened; tarsi comparatively large; claws heavy and strong.

Fifth instar:

Measurements: Length 8–10 mm.; maximum width 3.5–5 mm.

Body robust; mottled gray; anterior pronotal process porrect; pronotum entirely covering mesonotum dorsally; wing-pads fully developed, first and second pads extending about equidistant posteriorly; legs mottled.

Head much deflexed; frontal tuberosities small; eyes brown; ocelli white; clypeus distinct. Prothorax well developed and strongly chitenized; anterior process projecting far forward, cylindrical; mesothorax and metathorax distinct; wing-pads long, wings sometimes faintly visible through the pads. Abdomen greatly swollen; double row of blunt spines down dorsal line, smaller anteriorly and increasing in size toward the posterior end; nine segments distinctly visible; undersurface of abdomen greenish-white, in female sometimes showing impression of ovipositor. Legs strongly marked with patches of gray-brown; femora and tibiæ pilose; tarsi lighter in color; claws ferruginous.

Adult—Female:

Measurements: Length 11 mm.; length including horn 14 mm.; width between humeral angles 5.5 mm.

Gray with indistinct darker irregular markings; porrect cylindrical horn, slightly flattened and somewhat darker in color at the tip; tegmina hyaline, apex fuscous, almost reaching extremity of dorsal process.

Head including eyes twice as broad as long, grayish-yellow mottled with ferruginous and brown; margins of loræ strongly sinuate; clypeus pilose; eyes dark brown; ocelli white, nearer to each other than to the eyes and situated on a line drawn through center of eyes; beak extending to posterior coxæ; head very sparingly punctate and sparsely pilose. Thorax gray, deeply and densely punctate; median percurrent brown line sharpened into a ridge on extremity of horn and at apex of posterior process; sides of prothorax roughly and irregularly carinate; horn porrect and greatly variable in length, cylindrical except at extreme tip where it is flattened laterally; posterior process heavy, tectiform, gradually acute, almost straight, very slightly decurved and extending just beyond apex of tegmina. Tegmina hyaline, apex fuscous, base and costal region lightly punctate; under-wings hyaline, two-thirds as long as tegmina. Under surface of body gray-brown, pubescent. Legs uniform yellow brown; femora thick and smooth; tibiæ and tarsi densely pilose.

Male:

Differs from female in size and markings. Smaller, body somewhat less robust; porrect horn usually shorter and tending to curve; tegmina equalling apex of posterior process. Color deep chocolate brown; porrect horn almost black; apex of posterior process becoming cinnamon brown; a wide, brilliant, lemon-yellow longitudinal stripe on each side of prothorax, extending from margin half-way to median dorsal line, also small patches of yellow on metopidium; head yellow with brown patches. Undersurface of abdomen darker than in female.

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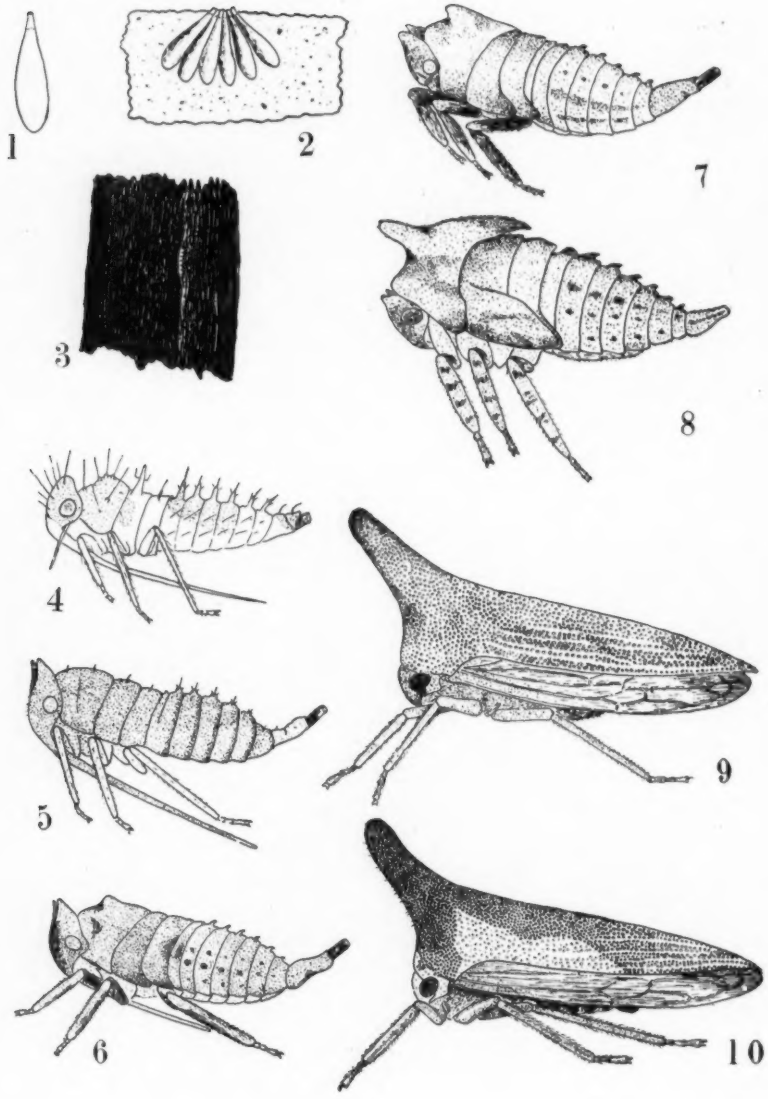
EXPLANATION OF PLATE IX.

Fig. 1. Egg.
Fig. 2. Egg-mass showing arrangement (Inside of bark).
Fig. 3. Egg-slit showing tips of eggs (Outside of bark).
Fig. 4. First instar.
Fig. 5. Second instar.
Fig. 6. Third instar.
Fig. 7. Fourth instar.
Fig. 8. Fifth instar.
Fig. 9. Adult female.
Fig. 10. Adult male.



W. D. Funkhouser.

THE DEVELOPMENT OF THE HAIRS UPON THE WINGS OF PLATYPHYLAX DESIGNATUS WALK.

By Wm. S. Marshall, University of Wisconsin.

While it has been assumed that the hairs on the wings of the Trichoptera develop in exactly the same way as those upon the wings of the Lepidoptera there is, so far as we know, no definite work to show that this assumption is correct. The following study was therefore undertaken to definitely ascertain, in some one species of Trichoptera, in what manner these hairs did develop upon the surface of the wings and *Platyphylax designatus* was selected for the work.

It has been impossible to find any works which could be given as an historical review of the subject and those papers having to do with the development of the wing of the caddis-flies have been given in a former paper (5). Dewitz (3), from whose work comes most of our previous knowledge of the development of the wings in this group of insects, does not take up the formation of the wing hairs. Spuler (9) distinguishes between hair scales and those hairs without a circular ring-like base for articulation and he shows a surface view of a portion of the wing of a Trichopteran, *Philopotamus scopulorum*, with a few of the latter hairs and four of the ring-like bases into which the hair scales are inserted. Regarding these structures he says: "Die gleichen Gebilde (hairs) finden wir auch bei den Trichopteren, gerade die Micropteryginen und Hepialiden, in der Flügelbidlung so nahe den allgemeinen Modus der Haarbildung vor sich. Dieselben werden von der Hypodermis gebildet. Jeder Stachel ist seiner Bildung nach unicellular." Tower (11) reaches a similar conclusion, saying: "In development the scales of Coleoptera follow exactly the same course as was found by Mayer (6) in the Lepidoptera."

The wings of *Platyphylax designatus* are more or less covered with hairs; these are present upon all the wings and on both surfaces although the anterior wings show a greater degree of pubescence than the posterior and the upper surface bears a much larger number of hairs than the lower. These hairs can be roughly divided into four groups: 1, vein and marginal hairs; 2, large surface hairs; 3, small surface hairs; 4, special long hairs.

1, vein and marginal hairs. The vein hairs are in most cases in a single row on nearly all of the longitudinal veins and are apt to be equidistant from each other; this is not true for the entire course of each vein as the hairs generally come closer and closer together in passing from the distal to the proximal part of the vein. Besides what one might call the ordinary vein hairs there are a number of very much smaller ones which, upon many of the veins, alternate with the larger hairs; on account of the prominence of the regular vein hairs these smaller ones are not at first likely to be seen. The vein hairs are mostly restricted to the upper surface and are more numerous and larger on the anterior than upon the posterior wings. The longest and thickest vein hairs are found near the base of the anterior wing, these are fluted, with many small ridges running lengthwise along the hair giving it the appearance of a cog wheel in transverse section (Fig. 1).

The marginal hairs, similar in size and structure to the vein hairs, are found not only upon the extreme margin of the wing but they extend for a short distance on to both the upper and the lower surfaces. In the anterior wing these hairs are longest, all lie close down against the margin and are directed toward the apex of the wing. Along the anterior margin of the posterior wing these hairs are similar in position to those upon the anterior wing but along its posterior and outer margins they are arranged perpendicular to it; these hairs as well as some upon the surface are plumose, the plumules are very small and not visible until the hairs are examined with a high power of the microscope.

All vein and marginal hairs are widest at the base and gradually taper to a point; they are hollow, nearly all are slightly curved and each fits into a raised ring-like cuticular opening on the surface of the wing.

2. Large surface hairs. Nearly all of these hairs are smaller than those just described, they are also heavier and darker and a little more curved. On the anterior wing these hairs are more numerous than on the posterior one and in both wings they are much more abundant upon the upper surface. On the posterior wing most of these hairs are on its outer third, except a narrow strip running along near the costal margin, and there are several large hairless areas, these are probably due to

the folding of the wing. The circular raised ring into which the hairs fit is smaller and less noticeable than the similar part for vein and marginal hairs. These surface hairs have a pointed distal end, with this exception their diameter changes but little and they do not become widened at the base.

3. Small surface hairs. These are very numerous and are scattered regularly on the surface, vein and margin. They are all nearly equal in size and are bent or hooked near the tip. A surface view of any part of either wing shows that these hairs come from nearly all of the hypodermal cells which have not taken part in the formation of one of the larger hairs.

4. The longest hairs are near the base of the posterior wings, they are much longer than the others and are present upon the surface and on the veins. These long narrow hairs are of equal diameter throughout except the pointed distal end. The ring-like cuticular thickening into which each hair fits is not directly upon the surface but situated upon a rounded papilla. In transverse section these hairs are seen to be fluted, much more deeply so than the large ridged vein hairs; the number of raised ridges varies from five to eight although six is by far the most constant number (Fig. 2).

When the pupa of *Platyphylax designatus* emerges from the last larval skin the wings are found at the sides of the thorax extending down against the legs and by these held from further extension in a ventral direction. In a surface view the wings are seen to have several longitudinal folds, Marshall (Fig. 23), and in section to have a fluted appearance along both surfaces. The wings soon begin to unfold and straighten until they are extended backward along the sides of the abdomen, Marshall (Fig. 25). The thickness of the wing does not at first decrease and in section the cells of the hypodermis are seen to be arranged in a fairly regular, single layer over the entire surface and just inside of the cuticula. The wings in their continued growth back over the body begin to decrease in thickness and at about this time there first appear those enlarged hypodermal cells from which the vein and marginal hairs develop; these are soon followed by the other enlarged cells between the veins from which the large surface hairs are formed.

Vein hairs. Just before the appearance of these above mentioned cells the hypodermis occupies a fairly even layer just

under the cuticula, cell boundaries are very hard to differentiate but the elongated, irregular, ovoid nuclei are fairly regular in their arrangement (Fig. 3). From the inner surface of the hypodermis come off a number of strands of protoplasm many of which, at this stage of the wing's development, pass across from surface to surface and connect the two layers of hypodermis with each other; these strands have nothing to do with the development of the wing hairs. The first indication of the trichogens, cells from which the hairs develop, is noticed in that certain of the nuclei of the hypodermis increase in size and then, with some of the surrounding protoplasm, push in from their original position towards the median part of the wing and away from the cuticula. These trichogens which first appear are situated adjacent to a vein and between it and the cuticula (Fig. 4). Nearly all of these trichogens lie along one side of the section; this is the upper surface of the wing upon which surface most of the hairs develop. The trichogen nuclei differ in position and size from the normal ones of the hypodermis, they also become more circular in outline but do not as yet differ in structure. At the same time that the trichogen nuclei wander away from the surface of the wing it is noticed that other nuclei go with them, these latter retain their normal size; they can be found in younger stages of the trichogen's growth (Figs. 5, 6, 7) and also after the hair has been developed (Fig. 8). What function these nuclei may perform is not known. This differs a little from the account of Mayer (6) who found that in Lepidoptera the trichogens first grow outward, towards the cuticula, while in Platyphylax we find that the movement is at first opposite to this and that the trichogens wander inward, away from the cuticula.

In the regular hypodermal cells each nucleus has one, sometimes two, rather small nucleoles which did not stain with hæmatoxylin or alum carmine. The trichogen nucleole, also non-staining, is at first similar to that of the other nuclei but enlarges with the growth of the nucleus until it becomes very noticeable (Fig. 6). At a later stage cell boundaries are more easily seen and the trichogens differentiate themselves from the other cells not only in this respect but also by the darker appearance of the cytoplasm; this fact, that the trichogens stain more deeply than the regular hypodermal cells was

noticed by Mayer (6). This is due to the secretary activity of these cells and shows that hair formation has already started (Fig. 7). At this stage it was difficult to find places where the young hairs could be followed for any distance because, during the wing's development, the hairs lie close against the surface and are shown in section as little circular or oval masses near the surface of the wing.

With the further growth of the trichogen its nucleus, also enlarging, begins to flatten out against the vein adjacent to which it lies; it becomes elongated and occupies a position with its longitudinal axis parallel to the surface of the wing. With the growth of the nucleus its nucleole, which has for some time been a single large one, changes and by some process, fragmentation or otherwise, becomes divided into numerous smaller pieces which are scattered irregularly around within the nucleus (Fig. 7). The flattening of the trichogen nucleus becomes especially noticeable after the decrease in thickness of the wing and it is always found to be pressed against an outer surface of the vein adjacent to which it lies. With this narrowing of the wing the nucleus not only becomes more flattened but may be bent and curved and, in studying sections, trichogens are found which contain apparently two nuclei but these are in reality sections through two parts of the same one. It might be well in this connection to mention that the vacuole, Mayer (6) or vacuoles, Schaffer (7), present in the trichogens of the Lepidoptera were not seen in Platyphylax.

After emergence of the imago sections show that the parts already enumerated are still present except the large trichogens which, as such, could not be found. The hypodermis is still present on both surfaces of the wing but the nuclei have become irregular in outline and many of them flattened against the cuticula. The functions of the trichogens ended they have undoubtedly decreased very much in size and lost their identity amongst the general hypodermal cells. (Fig. 8). This last figure does not show the final condition as the hypodermal layers become more reduced and in places almost entirely represented by the small irregular nuclei.

Large surface hairs. The special enlarged cells from which later develop the large surface hairs do not become differentiated until the trichogens of the vein and marginal hairs are plainly

visible, when they do first appear the wings have started to decrease in thickness. As already mentioned there is a stage in the development of the wing at which all cells of the hypodermis are similar and occupy an even layer just under the cuticula (Fig. 3); then some of these cells adjacent to the developing veins and at the margin of the wing increase in size and move away from the surface. With the exception of the trichogens at the two last mentioned places there is an even layer of hypodermal cells, all similar and equidistant from the cuticula, covering the areas between the veins and it is from some of these that the surface hairs develop.

Here and there in this even layer of hypodermis certain of the nuclei increase in size and move inward and away from the cuticula; these are similar to the enlarged nuclei which form the trichogens of the vein and marginal hairs except that the nuclei are different in their position on the wing and have no relation to the veins or margin. This is the first indication of the trichogens of the large surface hairs and when one (Fig. 10) is compared with the trichogen of a vein hair (Fig. 5) their similarity is apparent. Strands are seen coming from the free margin of the former and appearing very similar to part of the wall of a developing vein; they are, however, only some of the protoplasmic strands which extend from the hypodermis to the middle membrane ("Grundmembran").

As in the trichogens of the vein hairs the cytoplasm of these cells is often darker colored than that of adjacent cells and can be seen as dark streaks through the hypodermis (Fig. 11). From a surface view (Fig. 12) this same darker cytoplasm may be seen surrounding the nucleus of each trichogen but it is not noticeable in the other hypodermal cells. The same increase in surface of the nucleole that was noticed in the vein trichogens is seen, but to a less extent, in these nuclei (Fig. 13) and, when the secretion of the hair becomes active, several nucleoles are noticeable in each trichogen nucleus.

Small surface hairs. These hairs are so numerous upon both surfaces of the wing that there are very few hypodermal cells, excepting those taking part in the formation of the other kinds of hairs, from which one is not formed. In looking at the surface of a wing in which these small hairs have been developed one can examine many cells without finding one from which a small sur-

face hair has not been formed. The amount of secretion necessary for the formation of one of these hairs is comparatively small and no change is noticeable in the nuclei of the cells from which they come.

Upon the emergence of the imago these cells, as well as the trichogens of the larger hairs, decrease in size, loose their regular form and become small, irregular nuclei lying, as a rule, flat against the cuticula (Fig. 14).

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EXPLANATION OF PLATES X AND XI.

All figures drawn with a camera lucida. In all drawings the upper surface of the wing is to the left.

Cu., cuticula.
Tr. S., trichogen of surface hair.
Tr. V., trichogen of vein hair.
V., vein.

Fig. 1. Transverse section of a large vein hair. X 1700.

Fig. 2. Transverse section of one of the very long hairs found on the posterior wings. X 1700.

Fig. 3. Section through one wall of the wing from a pupa after the last larval skin has been cast and the body has started to contract. The cells of the hypodermis are as yet all similar and at no place in the section can any enlarged nuclei be found. X 1700.

Fig. 4. Section of a little older stage showing part of a vein, V, adjacent to which is an enlarged cell and nucleus, the beginning of a vein-hair trichogen, Tr. V. X 1700.

Fig. 5. A slightly older stage, after the wing has started to fold, showing three normal hypodermal cells and a vein-hair trichogen, Tr. V., near which is one of the other nuclei which move out with the trichogen. X 1700.

Fig. 6. A still older stage showing the enlarged nucleus of the vein trichogen. The greatest change over the preceding figure is in the much enlarged nucleole of the trichogen nucleus. X 1700.

Fig. 7. Section of a wing which does not as yet show the final folding. The nucleole shows the change from the single large one of the preceding stage. The cytoplasm of the trichogen is seen to be much darker than of the normal hypodermal cells and is extended out for some distance in the beginning of its development. Cuticula not drawn. X 1100.

Fig. 8. Section of a wing which has decreased very much in thickness. One vein-hair trichogen and two of surface hairs on upper surface. Middle membrane, M. m., through center of wing and connected by protoplasm to both surfaces. Cuticula not drawn. X 875.

Fig. 9. From transverse section of a wing of an imago soon after its emergence. Shows one vein hair and how the vein as well as other surface is covered by the small surface hairs. X 600.

Fig. 10. Four normal and one enlarged hypodermal cell, the latter has wandered a short distance towards the center of the wing and away from the surface; this enlarged nucleus, Tr. S., will later become that of a trichogen from which will develop one of the large surface hairs. X 1700.

Fig. 11. Two trichogens, Tr. S., of enlarged surface hairs showing the beginning of hair development. Cuticula not drawn. X 1100.

Fig. 12. Surface view of wing of about same stage as preceding. Four trichogens, Tr. S., and several normal hypodermal nuclei are shown. X 1100.

Fig. 13. Section of wing of pupa, wing folded within cuticular covering. One large and two small surface hairs. X 1700.

Fig. 14. Section showing one large and two small surface hairs. From an imago just after its emergence. X 1700.

Fig. 15. Three small surface hairs, from folded wing shortly before emergence of imago. X 1700.

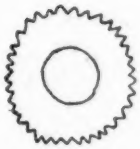

Fig. 1.

Fig. 2.

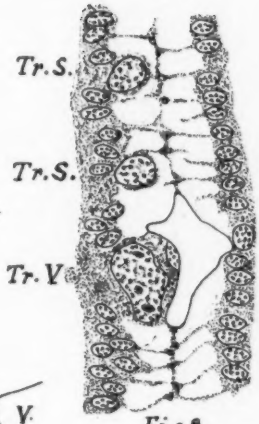

Fig. 8

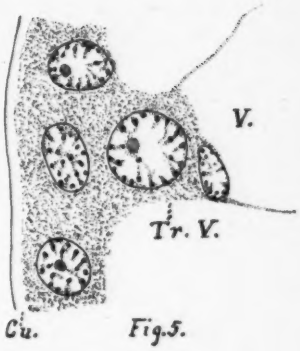

Fig. 5.

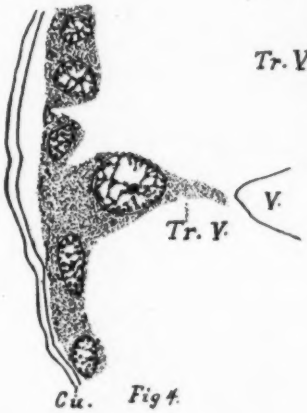

Fig. 4.

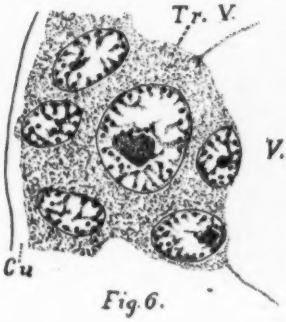

Fig. 6.

Fig. 3.

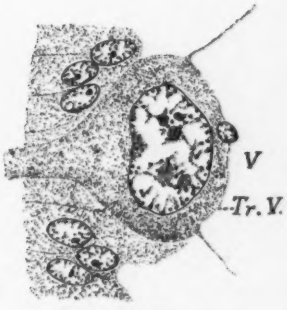

Fig. 7.

Wm. S. Marshall.

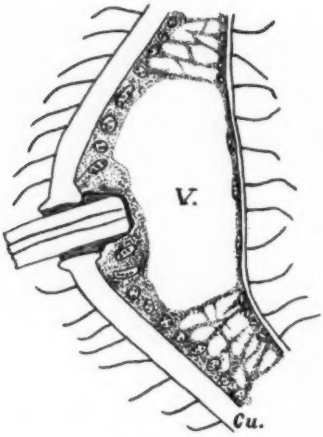

Fig. 9.

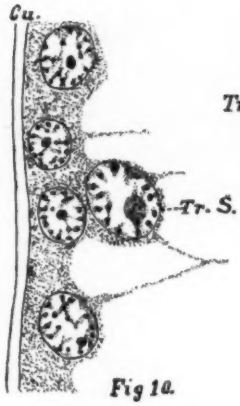

Fig 10.

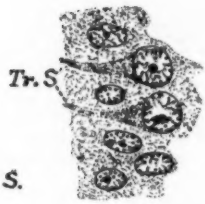

Fig. 11.

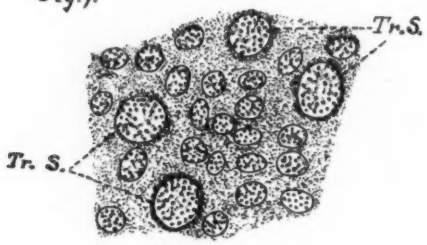

Fig. 12.

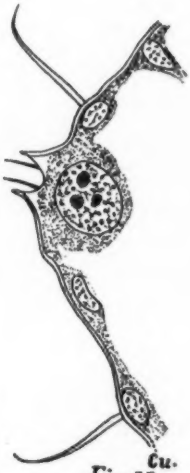

Fig. 13.

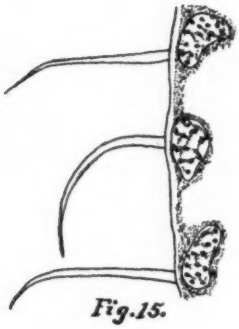

Fig. 15.

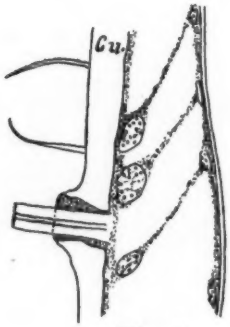

Fig 14.

Wm. S. Marshall.

THE BIOLOGY OF THE JUNIPER BERRY INSECTS, WITH DESCRIPTIONS OF NEW SPECIES.*

By S. Marcovitch,
Division of Entomology, University of Minnesota.

In the spring of 1913, Professor Crosby, of Cornell University, suggested that I work out the life history of two chalcids bred by him from deformed berries of *Juniperus virginiana* L. There was also an Eryophyid mite present within the berries, so that at first it was difficult to tell which one deformed the berries and what were the relations between them.

In the fall, I discovered a Tineid larva eating the seeds, while a little later, a Dipterous larva was found eating the fleshy portion of the berry. The latter has proved to be a new species of the family Trypetidæ. Since then, I have found a Cecidomyid larva, and have reared six species of chalcids from the berry, at least two of which are plant-feeding in habit. It seems rather remarkable, at first, to think that so many insects are able to find food in such a small fruit; yet when it is known what a role the mite plays, and how completely the berry is utilized, it does not seem so strange.

The Mite.—Character of the Injury. From the observations of others and from my own examinations, the berry was found to be deformed by the mite, it being classed as a mite gall. Massalongo, 1889, in describing this gall, thought that the mite penetrates the young ovule through the micropyle before the ovule scales become fleshy. Fertilization is thus hindered, and as the scales become fleshy as usual, it is probable that the physiological stimulus of fertilization necessary for growth is substituted by the pathological stimulus of the parasite. Whether or not fertilization is hindered would be difficult to say, as the stigmas of the ovules were open during the beginning of the work of the mites, and once a mite entered the ovule, the berry was found deformed.

The normal berry is more or less cone-shaped while the one-seeded, deformed berries assume a chestnut shape. In the two or more seeded berries, however, the deformation assumes

* Begun at Cornell University; completed at the University of Minnesota.

somewhat the shape of a dumb-bell (Fig. 6, Pl. XII). The mites go in and out through two openings, located at the ends of the berry. These openings are in many cases elevated, and shaped like a miniature volcano, measuring about one-sixth of a millimeter wide at the top. The areas surrounding the openings are yellowish, circular in outline, and very much hardened, thus probably preventing the tissue from growing around the opening by which the mites go back and forth.

Just how this area became hardened, and the various stages leading up to the deformed berry were unknown. At flowering time, however, on May 27, the mites were found in the beginning stages of their work, and the various steps leading up to the deformed berry were traced. Some remarkable changes were found and the interesting feature learned was that the outer hardened area was ovule tissue, and the opening in the center, the stigmal opening of the ovule. In the flower stage, two or three upright ovules are visible (Fig. 1, Pl. XII) surrounded by somewhat thickened scales. A little later, the scales become fleshy and grow over the ovules (Fig. 3, Pl. XII) which seem to sink into the berry after fertilization takes place. If attacked by a mite at this time, the ovules do not sink into the berry, but broaden out and remain on top, the scales growing around them (Fig. 4, Pl. XII, a). The opening of the ovule, then, becomes the opening by which the mites pass back and forth, while the body of the ovule becomes the hardened portion surrounding the opening.

A cross-section of a young, deformed berry about a week old already shows the openings by which the mites pass back and forth to be formed from the old micropyle (Fig. 5, Pl. XII). From this opening, a narrow path leads down into the berry, where it enlarges into a circular burrow. Here one or two reddish mites and from two to ten greenish-white eggs are to be found. After a mite has entered a berry, it becomes deformed and fleshy, the seeds failing to develop. It is probable that the fleshy portion of the deformed berries is made up of more ovule tissue than the normal berries. In this spongy portion, the two phytophagus chalcids are found feeding (Fig. 5, a and b, Pl. XVIII), as well as the mites. The chalcids may, therefore, be considered to be inquilines, since they live in the abode of the mite.

Eriophyes quadrisetus typicus (F. Thom.)*. The body is cylindrical, annulated, gradually tapering to posterior segments. It is very similar to *P. pini*. The body is shorter than in *P. pini*, being about 3 or 4 times as long as broad. The dorsal scutum possesses striations that are not very distinct, one of which is found on the median line and one on each side, both diverging at the posterior end. Laterad of these are two arcs of circles, one on each side, with the concave surfaces facing outward. Near the margin are others that are also curved and incomplete. Seta dorsalis is borne on the sides of the cephalothorax, at a noticeable distance in front of its posterior curvature. It extends forward and upward and beyond the base of S. L., if bent backwards. S. L. are very long, being the longest of the ventral setæ of the abdomen. Caudad of S. L., S. V. 1 are found to be shorter than S. L. S. V. 2 are short, while S. V. 3 attain the posterior extremity of the body. Besides the above-named S. D., there is, further behind, another pair of S. D., which are very short. At the anterior extremity of the scutum, there exists a minute frontal seta. The setæ C. P. are well developed. The S. C. A. are longer than in any other species and very stout, (.025 mm.). S. G. are well developed. The rings are of the same character on both sides. The fifth joint of the legs is somewhat longer than the fourth, having at the end a small, distinct comb with seven pairs of small hairs. The tarsal claw is just a little longer than the comb. The valves of the epigynum are smooth, the posterior one being square.

Length of female	.25 mm.
Width of female	.07 mm.
S. D. anterior	.07 mm.
S. L.	.04 mm.
S. V. 1	.03 mm.
S. C. A.	.02 mm.

Eriophyes quadrisetus juniperus. On January 23, some berries received from Professor C. O. Houghton, of Newark, Del., were found to be deformed in a different manner. Upon examination Mr. Hodgkiss reported the mites to be *Eriophyes quadrisetus* juniperus. In this case, the berry was not fleshy throughout, and seeds were present, the tips of which stuck out of the berry in a conspicuous manner. The normal berries are

* Translated from Canestrini and identified by Mr. Hodgkiss of the Geneva Experiment Station.

blue while the ones infested with this latter variety are green and smaller, the mites being present within the seed. In Europe, *E. quadrisetus* typicus is said to deform the berries of *Juniperus communis* in a somewhat similar manner while *Eriophyes quadrisetus* juniperus works at the bases of the leaves, causing them to swell (Laggerheim 1899).

Egg. The egg is translucent and whitish. It is oval in shape, with bluntly rounded ends. The longer axis measures about 50 μ, and the shorter axis about 35 μ. They occur in great numbers in the berry during the growing season.

Life History. The winter is spent by the mites within the berries, principally in the greener ones and those not eaten out by the chalcids. With the approach of spring, the mites become active, leave the berries, many of which are still on the tree, and begin entering the young ovules. These soon become deformed and eggs are laid in them. Here the young find sustenance and make channels radiating out from the original, central burrow. Through the tiny openings at the ends of the berry, the adults pass to and fro and seek other berries, just past the flower stage, to start new colonies. The production of the young is continuous throughout the growing season. During October, the mites begin to collect in certain berries where they pass the winter, losing most of their greenish color and becoming brownish.

The berries of mature trees are, practically without exception, deformed by the mites, while those of young trees are usually normal. It seems probable that the berries develop quicker in the latter case before the mites have a chance to enter the ovules; while on the old trees, the berries develop slowly enough to enable the mites to get out of their hibernating quarters, and find the ovules before they have become sunken.

The Juniper Berry Chalcid.

Eurytoma juniperinus, n. sp.

Life History. This species is plant-feeding in habit and found in the fleshy portion of the deformed berries, but never in the seed tissue of *Juniperus virginiana.* There is but one generation a year and the winter is passed in the larval stage. On May 26 the insect was already found in the pupal stage, while on May 29 adults were observed emerging. On June 26

an egg was found in the central burrow of the mites, as shown in the diagram (Fig. 6, b, Pl. XVII). The egg was removed to note the length of the egg stage, and after two days of warm weather, the embryo could be seen to be already formed. The head was located on that end where the long pedicel arises from the egg (Fig. 7, Pl. XII), thus agreeing with Triggerson's observations with respect to the orientation of the embryo in the egg (Triggerson, 1914). The mandibles could be seen to be working back and forth in a lively manner, while in the caudal half of the egg could be seen in motion, some oil globules. The neck of the egg was shrunken while the pedicel was curled back over the body of the egg. These larvæ are quite abundant in the mite-infested berries, two or three being often found. They are comparatively active, move about, and devour large portions of the berry (Fig. 5, a, Pl. XVIII).

Female.—Length 2 to 2.3 mm.; thorax 0.7 to 0.8 mm.; abdomen 1 to 1.3 mm. General color black (Fig. 1, Pl. XIII); scape and part of pedicel brownish, rest of antennæ black. Color of legs variable; hind coxæ, femora except knees, and tips of tarsi, black; rest of legs suffused with brownish. Head seen from above transverse, concave behind and convex in front. From the base of the antennæ to clypeus there is a low smooth elevation. Antennal furrows with the sides straight or slightly convergent below. Head and thorax umbilicate-punctate; propodeum coarsely rugose on the sides, the longitudinal median depression broad and shallow, densely and distinctly reticulate-punctate throughout, except sometimes for the longitudinal furrow which is crossed with small transverse ridges. The anterior portion of the propodeum contains three longitudinal carinæ enclosing a smooth quadrilateral area. On the cephalic face of the front coxæ there is a deep diagonal furrow bounded in front by a distinct ridge, which makes a sharp turn near the upper angle. Wings hyaline.

Abdomen conic-ovate, smooth, about three-fourths as wide as long, with a fine sculpture on the anterior half of the segments but fading out on the dorsal surface. Hind margins of segments 2, 3, and 4 nearly parallel (Fig. 3, Pl. XIII). Viewed from the side the dorsal surface of the abdomen presents a nearly straight line, except at the ends. Segments 2, 3, and 4 subequal; the 5 longer than the 3 and 4 together; 7 a little longer than or subequal with the 6. The 6, 7, and tip of sheaths of ovipositor clothed with fine white pile.

Many of the cotypes vary in having more brown on the face, the venter of the prothorax and part of the mesothorax, the abdomen beneath, and legs.

Male.—Length 1.6 to 2.1 mm.; abdomen 0.7 to 0.9 mm. Similar to the female in coloration but much more variable, so that some specimens are nearly all red, all gradations being found. Pedicel and scape brownish, the latter markedly dilated above. In the darker forms, only the proximal portion of the scape is brownish; rest of antennæ dusky. Wing veins brownish or yellowish. The first funicle joint slightly longer than the second, the rest subequal and arched above. Petiole and hind coxæ finely reticulate, the latter about three-fourths the length of the former. Sometimes a brownish spot is present in the darker forms on the upper angle of the prothorax.

Variety Crosbyi.— ♀ similar to the above in coloration and size. The dorsal surface of the abdomen is evenly curved, and not as straight as in *E. juniperinus*. The posterior margins of segments 2 and 3 are nearly parallel, while the posterior margin of the 4 segment meets that of the 3 on the ventral surface. The tip of the abdomen appears to be rather sharp-pointed. The anterior border of the segments of the abdomen with a fine sculpture, that does not fade out on the dorsal surface. Viewed from above all the segments are not visible due to the greater curvature. This form may be a distinct species, and as I intend to work on this genus, further consideration will be given it at a later date.

Described from numerous specimens reared from the berries of *Juniperus virginiana* at Ithaca, New York.

Cotypes deposited in the entomological collection of Cornell University, and in the author's collection, University of Minnesota.

Larva.—(Fig. 1, Pl. XIV). Length about 2.3 mm. Color dull white, mandibles (Fig. 3, Pl. XIV), brownish with a large, sharp tooth in its inner edge. Head and antennal tubercles distinct (Fig. 2, Pl. XIV). Just back of the mandibles is a thick, fleshy labium, slightly lobed and extending beyond the mandibles. On the under side of the labium there is a minute spine, which is elevated on a small tubercle. The setæ on the head and thorax are medium in size, spine-like, and arise from small tubercles, there being eight on the head, ten on each thoracic segment and four shorter ones on each of the abdominal segments. On the mid-dorsal line of each abdominal segment is a large, rounded tubercle, more distinct when the larva is killed in hot water. The spiracles are nine in number, as shown on the diagram, (Fig. 4, Pl. XIV), there being one on the meso- and metathorax, and one on each of the first seven abdominal segments.

On January 10 some of the larvæ were placed in vials on cotton, to check up the adult stage. Similarly, five different kinds of larvæ were taken out of the berry and checked up with the adult forms. The larvæ of *E. juniperinus*, when taken indoors, will pupate in about ten days, gradually turn black, and emerge about four days later.

The Juniper Berry Geniocerus.

Geniocerus juniperi Crawford

This species has been proved to differ from all the other known members of this parasitic group in that it is plant-feeding in habit. They are, by far, the most abundant, there being often as many as eight or ten larvæ in a single berry. The young larvæ were observed from the time they were visible until they were full-grown, and found to live in tight-fitting burrows (Fig. 5 b, Pl. XVIII), that gradually become larger as the insect feeds and grows. This fact alone is sufficient to establish its plant-feeding habits. It is very inactive and a moderate feeder, as compared with the Eurytoma larvæ. There is but one generation a year, and the winter is passed in the larval stage.

"*Female.**—Length about 1.5 mm. Lemon-yellow, with dark brown markings on the rear of the head, front of pronotum, and small brown spot on each lateral angle of pronotum, one on front of axillæ, suture between mesoscutum and scutellum; propodeum medially; spot on each side of abdominal segments and the apical margins of segments more or less suffused with brownish; scape yellow with a brown spot above, rest of antennæ brownish; joints of funicle elongate; seen under high power the antennæ show three ring joints; head and thorax finely sericeous; median furrow of mesoscutum rather indistinct, median pair of furrows on scutellum about half as far apart as length of scutellum; propodeum with median carina hardly as long as the metanotum; submarginal vein with about four bristles; legs yellow with the apical joint of tarsi brown; ventor along median line somewhat brownish; sheaths of ovipositor apically distinctly brown.

Paratypes vary in having more brown, the mesoscutum medially with a large brown spot in front; vertex, parapsidal areas anteriorly, sides of propodeum with brown spots; the abdomen with the bands more pronounced."

As the males are very much fewer in number, I did not succeed in locating one in my rearings until January 2, 1915.

Male.—Length 1.2 mm.; abdomen 0.5 mm. Color lemon-yellow, but the whole dorsal surface much darker than in the female. These darkened areas are more pronounced on the rear of the head, propodeum, furrows of scutellum, and abdomen. The latter has the dorsum brown, excepting for the anterior and posterior extremities, while the apical margins of the segments are darker. The whole ventral aspect lemon-yellow, except for a small area on the prothorax. The antennæ are

* Female to be described by J. C. Crawford, Proc. Ent. Soc., Wash. Male described by author.

similar to *G. marcovitchi* (Fig. 8, Pl. XV). The first joint of the funcile about as long as the pedicel, second joint slightly shorter than the third; third and fourth subequal; club as long as the two preceding joints. Under high power, two ring joints are visible.

Egg.—The egg as dissected out of the female is club-shaped, whitish, with one end wider than the other. Length 0.45 mm.; width of wider end 0.075 mm.; width of opposite end 0.033 mm. (Fig. 14, Pl. XV).

Larva.—Length 1.5 mm. by 0.9 mm. wide. Color dull white with brownish mouth parts. The larva is apparently smooth all over (Fig. 6, Pl. XIV). The head and thorax are not differentiated, the former being reduced to a conical projection, on the end of which are situated the mouth parts. Looking down upon the head, the mouth parts are seen to be situated in a ring (Fig. 7, Pl. XIV), which is heavily chitinized on the dorsal half and to which are attached three prominent lobes, the middle one being the largest. Viewed from the side, these lobes project backward so as to appear like teeth. Within the center of the ring are the two mandibles that project downward into the mouth cavity. Just above them are two slender processes in each side of the ring that might be termed the maxillæ.

Natural Enemies.

On October 30, 1914, I found a parasitic larva in contact (Fig. 9, Pl. XV) with one of the Geniocerus larva, the latter being discolored and dead. Later this species bred out to be *Geniocerus marcovitchi*, Crawf. (Proc. Ent. Soc. Wash., 1915). These parasites breed out in large numbers, and are among the first insects to emerge from the berries when taken indoors. There are apparently two generations and the winter is passed in the larval stage. As the berries remain greenish and pulpy, they would have no difficulty in ovipositing in the fall. Oviposition was observed in the usual way on August 13, lasting about two minutes. When the ovipositor was withdrawn it would apply its mouthparts to the exact spot where it had oviposited, apparently feeding. After a few minutes it would again oviposit in about the same spot, and then feed again. This operation was repeated several times.

Geniocerus marcovitchi.

"*Female.*—Length 2 mm. Blue black or greenish black; joints of the funicle elongate, under high power the antennæ show three ring joints; mesoscutum finely longitudinally sericeous, median furrow on mesoscutum indistinct; metanotum with two yellow spots on disk; propodeum with median carina short, hardly as long as the metanotum; submarginal vein with three or four bristles; legs blue black, the knees, extreme bases and apices of tibiæ and tarsi except apical joint whitish.

Male.—Length 1.75 mm. Similar to the female, the first joint of the funicle about as long as the pedicel, much shorter than the second joint, joints 2 to 4 being subequal in length, club not enlarged, almost twice as long as last joint of funicle, tibiæ yellowish white with a brown stripe inwardly."

Larva.—Length 1.6 mm. and 0.7 mm. wide. Color dull white. The anterior end of larva wider than posterior end, with the head segment rounded. Mandibles very small and pointed. The larva is smooth all over, and composed of fourteen segments.

Egg.—The egg of this species is more or less club-shaped, one end being provided with a long process, while the other end is rounded and tapering (Fig. 13, Pl. XV).

Another parasitic larva was found in the berries but as yet I have not been able to determine its host (Fig. 11, Pl. XV), although it might be parasitic on the Eurytoma larva or phytophagus. When a berry is cut in two, the larvæ are usually to be found in a vertical position and sometimes quite numerous. This larva is rather elongate, spindle-shaped, and pointed at both ends, the hind end being somewhat less acute. It is brownish in color, but lighter at both ends. In the middle of the larva can be seen a conspicuous uric acid concretion that is visible through the skin. There appear to be fourteen segments, with the anal segment bearing two minute spines and slightly lobed. After boiling in caustic potash, the mouth parts are seen to consist of two tiny, pointed mandibles. The pupa is at first brownish in color but later turns black. The sheaths covering the mandibles and lateral edges are very prominent. Length of pupa 1.4 mm., width 0.7 mm.

The Juniper Berry Fruit Fly.

Rhagoletis juniperinus, n. sp.

In the latter part of September, 1913, a Dipterous larva was found feeding upon the fleshy portion of the Juniper berry, at Six-Mile Creek, Ithaca, N. Y. Some were kept indoors, and on April 6 one adult emerged. After careful comparison with many descriptions of related forms, Professor Johannsen found it to be distinct, although closely related to *R. ribicola* Doane.

Life History. It was not until the afternoon of August 12, that an adult male was observed on the tree. On August 21 females were found ovipositing, the process of which lasted about one minute, during which time the ovipositor was worked at an angle of 45 degrees. Just beneath the skin, at this angle,

an egg was later found and dissected out. The egg punctures, which can be found on all sides of the berry, appear as small brown spots, visible to the naked eye, and sometimes with a distinct opening. The fact that the flies appear so late, as compared with other members of the genus, is another example of the adaptation of the time of emergence to the proper stage of the development of the particular fruit. The larvæ mature about October 9, although a few were found in the berries October 27. They pupate about an inch below the surface of the ground. On October 8, however, some were found to have pupated within the berries, which had been picked about two weeks previous, and kept in a glass jar. Two or three pupa were often found within these berries, and once even five, although the berries when examined on the tree, were found to contain but one larva. No holes of any kind were visible on those berries which had been kept in the glass jar. The larvæ eat the fleshy portion of the normal berries and as the young trees have a greater proportion of normal berries, they are much more numerous there.

Female.—Length 3.2 to 4.2 mm.; thorax 1.3 to 1.8 mm. General color, black; head yellowish or brownish; ocellar area dark with space between ocelli and compound eyes more or less suffused with brownish; occiput yellowish brown, except for a few darkened areas which are sometimes arranged radially; antennæ brownish, with the anterior corner of last joint rather sharp; arista black, except for proximal portion; bristles black, except for the post-verticles, which are yellowish. The three facial pairs of bristles convergent, the ocellar pair strongly proclinate, the two fronto-orbital, and vertical pair strictly reclinate (Fig. 6, Pl. XIII).

Thorax shining black with four longitudinal, yellowish bands on dorsum—the inner pair projecting farther forward, and confluent in front. Scutellum black, except for a white rectangular spot on the hinder portion; halters yellow. A striking, bright, alabaster-colored band runs from the humeri to the base of each wing. The thoracic and four scutellar bristles, black.

Abdomen, shining black; posterior border of segments 2, 3, 4, and 5, with a rather broad band of white, the band of the 6th much narrower. Femora, except tips, black, front pair often lighter; tibiæ, trochanters, and tarsi except tips, yellowish-brown; coxæ black, lighter at tip. Wings hyaline, marked with four brown cross bands, as in *R. ribicola* Doane. The first is somewhat oblique, and runs from the humeral vein to the sixth longitudinal vein, along which it gradually fades out beyond the posterior basal transverse vein. The second is much broader, nearly perpendicular, begins on the costa, between the tips of the axillary and

the first longitudinal vein, and extends across the middle of the fifth longitudinal vein, fading out before reaching the posterior margin of the wing. The third is nearly parallel with the second, not quite as broad, runs over the posterior cross-vein and reaches the posterior margin just behind the tip of the fifth longitudinal vein. The fourth band is oblique, completely united with the third on the costal border, and reaches the posterior border at the tip of the fourth longitudinal vein. First longitudinal vein with short, black, bristles. Anterior cross-vein a little oblique, and slightly curved. Anal cell drawn out to a distinct point (Fig. 4, Pl. XIII).

Described from six females and three males, reared from berries of *Juniperus virginiana* at Six Mile Creek, Ithaca, N. Y.

Types in the author's collection, University of Minnesota.

Paratypes deposited in Cornell University.

According to Doane's table of the North American species of Rhagoletis, the present species runs down to *R. ribicola* Doane. The two species may be separated by the following characters:

Anal cell drawn out to a distinct point, spot on scutellum white and small... **juniperinus**

Anal cell not drawn out to a distinct point, spot on scutellum light yellow and larger ..... **ribicola** Doane.

Larva.—Length 6 mm.; width 1.4 mm. Generally dirty white, sometimes slightly greenish (Fig. 1, Pl. XVI). Body rather stout, tapering very little in back, but more in front. Two great hooks (Fig. 11, Pl. XVI). The anterior spiracles (Fig. 6, Pl. XVI) are funnel-shaped, ending in eleven or twelve lobes, each of which, in turn, seem to end in a number of minute pores. The base of the spiracle is made up of polygonal areas. A spinulose area on either side of the dividing line, between segments, from the third and onward, becoming more pronounced towards the venter, where they form the ventral fusiform areas from the fifth to the twelfth segments. A small transverse line is visible on the middle of each ventral segment. The anal tubercles are prominent, and slightly convex. The stigmal plates are about twice their diameter apart, slightly elevated (Fig. 3, Pl. XVI), and composed of three straight slits directed towards the base of the opposite plate (Fig. 10, Pl. XVI). Between the stigmal plates and the anal tubercles are two pairs of distinct fleshy tubercles (Fig. 2 and 3, Pl. XVI), the two nearer the anal tubercles being smaller and a little closer together.

Egg.—Length 0.64 mm.; width about one-fourth of the length. Color whitish with the proximal end yellowish; tip or pedicel brownish. Egg is smooth all over (Fig. 8, Pl. XVI).

The Juniper Seed Caterpillar.

Argyresthia alternatella Kearf.

On September 1, a small caterpillar was found within the seeds of the berries at Six-Mile Creek. On February 12 two moths emerged, and were identified by Mr. August Busck as *Argyresthia alternatella* Kearf. He also informed me that the early stages and life history were unknown, the moths having been collected by Kearfott in 1908.

Life History. By May 24 the moths were found flying about the trees, and on June 6, eggs were found. These were laid on the stems just below the berries (Fig. 6, Pl. XVIII), while a few were also found lodged on the tips of the scales. By June 24 the berry in cross-section showed three concentric layers within the fused scales. It is probable that the outermost layer, being a part of the ovule, divides and fuses with the scales to form the fleshy portion of the berry. The second layer probably becomes the hard seed-coat, while the inner one becomes the endosperm. It was in the third layer that the earliest stage of the caterpillar was found (Fig. 6, a, Pl. XVII), working its way into the seed, while the seed-coat is still soft, and consuming many of the seeds. The mature larvæ feed on the fleshy portion of the mite-infested berries and, to some extent, on that of the normal berries. The larvæ become full-grown about September 25 and emerge from the berry to build their white, silken cocoons. A few, however, were found in the berry October 30, together with a parasite in contact with one of them. While digging for the pupæ of the fruit flies, I came across the small, silken cocoons, which are formed on the ground, just beneath the grass and sometimes attached to small sticks. The seeds infested by the caterpillar seem to be slightly larger and rounded in shape, while the mite-infested berries are dumbbell-shaped.

"*Adult.**—Head white, palpi golden, antennæ golden fuscus, basal joint paler, thorax white, patagia and posterior end golden; abdomen and legs whitish-ochreous. Expanse 10–12 mm.

Fore-wing. Golden-ochreous, reticulated with brown oblique faciæ. There are five brown spots on costa, about equally spaced between inner 6th and outer 5th. There are three similar spots on dorsal margin at inner 4th, middle and outer 4th; broken brown facia join the costal and dorsal spot, somewhat like a double or jointed letter WV. There is a

* Description from Kearfott. N. Y. Ent. Soc. **16**: 182.

streak of brown on dorsum at base and the apex of the wing is lightly reticulated with this color. Cilia light brownish ochreous on costa and upper half of termen, becoming pale fuscus below middle.

Hind-wing. Light fuscus, cilia with a faint ochreous tinge."

Pupa.—About 4 mm. long by 1.3 mm. wide (Fig. 4, Pl. XVIII). General color greenish, becoming brownish toward maturity. Eyes reddish in mature pupæ. Head, tip of wing pads, tip of abdomen, and 5th, 6th and 7th abdominal segments darker than the rest of the body. General shape cylindrical with abdomen pointed, ending in about seven or eight stout, black spines and reaching a little beyond wing pads. Head bears two conspicuous setæ on each side of the top, two setæ on the front, just laterad of the eyes, and one on each side of the back of the head. A row of eleven smaller setæ on the center and on each side of the dorsum. Six spiracles visible.

Larva.—Length 7 mm. by 1.5 mm. wide (Fig. 1, Pl. XVII). Head brownish, ocellar area, anterior margin of head, and a fine line extending from the ocellar area to the first segment, dark brown. The anterior half of the thoracic and the first eight abdominal segments with an orange-colored band which is more prominent on the dorsal half. The bands of the second and third thoracic segments are somewhat narrowed on the dorsum while that of the first thoracic segment is lighter. The last two segments suffused with red, nearly all over. The remaining portion of the body of the larva is yellowish. Some of the larvæ, however, show very little of the orange color on them. The mandibles are strong bisetose and quadridentate, the two inner teeth being the larger (Fig. 2, Pl. XVII). The antennæ are three-segmented and borne on a fleshy membranous cone (Fig. 3, Pl. XVIII). The first segment is wider than long while the second segment is slightly longer than wide, truncate, and bears a long seta on each side of its apex as well as a small spine and two tubercles, which are about three times as long as broad. The minute third segment is borne on one side of the center, the apex of which bears three small spines and two tubercles, one of which bears a seta and is half as long as the other. The arrangement of the setæ on the third abdominal segment is shown in the diagram (Fig. 7, Pl. XVII). The hooks of the pro-legs and spiracles are brownish, the latter surrounded by a small, circular, yellowish area. The thoracic legs are large at the base but taper rapidly (Fig. 3, Pl. XVII). The first eight abdominal legs are wart-like, ending in about nine hooks that are arranged in a circle, somewhat open on the outer end (Fig. 5, Pl. XVII). The number of hooks seems to vary, thirteen being the highest number found. Pro-legs have about seven hooks. There are nine spiracles, one on the prothorax and one on each of the first eight of the abdominal segments, located in the middle of the orange-colored band.

Egg.—Length 0.33 mm. by 0.2 mm. wide. Shape oval; color, greenish white, with a tinge of purple. The eggs found on the stem are somewhat flattened on the under side, but less so when found on the scales of the berry. The surface of the egg is covered with numerous wavy ridges (Fig. 7, Pl. XVIII).

NATURAL ENEMIES.

Secodella sp.—A few specimens of a very beautiful, large, blue chalcid were reared in the winter of 1913 and occurred in much greater numbers the following year. A larva differing from those usually found in the Juniper berries was discovered in December, 1914, among the large particles of excrement characteristic of the Tineid larvæ; hence, I assumed that it was parasitic on the Tineid. After placing a few in vials, the large blue chalcid bred out, the females of which are long and possess a tapering abdomen. This whole subfamily are external feeders on Lepidopterous larvæ. Mr. Crawford of the U. S. National Museum has just informed me that this is a new species, and belongs to the genus Secodella.

Larva.—Length 2.2 mm. General color dull white, with the middle segments brownish (Fig. 6, Pl. XV). Head distinct, with a tubercle on its dorsal surface (Fig. 7, Pl. XV). Antennal tubercles whitish and very prominent. Two tiny, pointed mandibles. In some specimens, the spiracles and tracheal system are visible. Prothorax provided with four minute spines while the other segments apparently do not have any.

Family Encyrtidæ.—On October 17, I dissected out of the caterpillars six parasitic larvæ which were greenish in color and about 1.8 mm. long. The host larva was apparently healthy and crawled around naturally, although a small swelling was visible on one of the abdominal segments. It seems that only about three of the parasites mature in one host larva—the pupæ of these arranging themselves in a peculiar manner. The host larval skin is pushed in, in two places so that the outlines of three pupæ are visible, the anterior one having the head and legs of the host attached to it (Fig. 4, Pl. XVII). The adult is a pretty chalcid, the male having beautifully branched antennæ (Fig. 1, Pl. XV). According to Ashmead's table, this species runs down to the genus Prionomitus (?). I reserve the description of these parasites for a later date.

Protapantales sp.—A few parasites belonging to this genus, as determined by Professor Bradley, were reared. The adults were observed ovipositing on June 11, while the eggs of Arygyresthia were still attached to the berries, hatching at this time. Just before ovipositing, the abdomen is extended and the hind legs are rubbed against each other and over the ovipositor.

Another parasite belonging to the Ichneumonidæ was reared. This species was also found when I opened a pupa of Argyresthia which looked paler than the rest.

The Juniper Berry Midge.

On October 14, 1914, the berries growing along the bluffs of of the Mississippi River, near St. Paul, were found to contain a reddish Cecidomyid larva, together with a Tetrastichus larva in the same cell. The midge larvæ are found only at the bottom of the berry, close to the stem (Fig. 5 c, Pl. XVIII), there being often two or three in one cell. The adults have not, as yet, been bred out. The larva is orange-colored, measuring about 2.5 mm. while the breast bone is elongate, as shown in Fig. 8, Pl. XII. These larvæ were not found to be present in berries from Ithaca, New York.

Distribution and Uses of Juniperus.

The Junipers are widely distributed over the United States although usually not very abundantly. The berries having a rich, aromatic odor, are as yet of no great economic importance. They are, however, used in medicine and, to some extent, by the Germans who use them in making gin and flavoring sauer kraut. They also furnish food for birds. Of greater importance than the berries is the timber furnished by the Juniper trees, the propagation of which is attended with some difficulty. As a result, I have had a number of inquiries regarding sterility of the seed, so that a study of the seed-infesting insects has an economic importance. Berries were received from many locations, as follows:

Boston, Mass.—On October 29 some berries of *Juniperus communis* were received from Boston but were not infested.

Morganstown, W. Va.—Received berries February 1 and found them infested.

Blacksburg, Va.—Received berries January 20 and found the mites present in great abundance, as well as the larvæ of *Geniocerus juniperi*. There was also evidence of the work of the Trypetid larvæ.

Taney County, Mo.—On November 16, received some berries of *Juniperus virginiana* but found them normal.

Kansas State College.—Received berries on November 16 from Charles A. Scott, found no trace of the mites, but did find evidence of the work of the Trypetid and Tineid larvæ.

Pullman, Wash.—Received berries on November 18 from the grounds of the campus but they were not infested.

Durham, N. H.—On November 26 some berries of both *Juniperus virginiana* and *J. communis* were received from Professor Foster. The former were normal but the latter were found to contain Eurytoma larvæ within the seeds of only the green berries, the blue ones apparently not being infested. There was no trace of the mites, but found an egg of the Eurytoma within the seed together with the Eurytoma larvæ.

College Station, Tex.—Received berries on December 28 from Professor A. T. Potts and found them normal.

Fort Collins, Colorado.—On November 10 some berries of *Juniperus scopulorum*, a western species of Juniper, were received. The berries were dried up but found adults of Eurytoma within the seeds, with no trace of the mites. By the presence of the excrement the caterpillar was apparently present.

St. Paul, Minn.—On October 13 berries along the bluffs of the Mississippi River at Fort Snelling, were examined. The mite was present, as well as the Eurytoma and the Tineid and midge larvæ. These berries were very similar to the ones found around Ithaca, New York, excepting that I failed to find the Geniocerus or Trypetid larvæ.

Newark, Del.—On January 23 berries were received from Professor C. O. Houghton. Some dead adult Eurytomas, which were very small, were also found in the seeds. Sometimes a brownish yellow larva, probably belonging to the genus Tetrastichus, was encountered within the deformed seeds that might be parasitic on the Eurytoma, although I was unable to find any evidence.

Logan, Utah.—February 13, received berries from George R. Hill. These were found to be infested by the mites, and there was evidence of the presence of the caterpillar. The berries were not deformed, the species being *Juniperus utahensis*.

I wish to thank all of the above named for kindly sending me berries of the various Junipers.

Method of Work.—Drawings and measurements were made from larvæ killed in hot water and, where possible, from parts mounted on slides. Trachea were studied by putting a few drops of caustic potash or chloroform on the larva and then placing a cover glass over it.

Acknowledgment.—I wish to thank Professors Crosby and Johannsen for their many kind suggestions throughout the work and especially Professor Crosby, at whose suggestion the work was undertaken, and whose aid was invaluable throughout the study.

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EXPLANATION OF PLATES.

PLATE XII.

Fig. 1. Flower stage of *Juniperus virginiana* showing the upright ovules.
Fig. 2. Flower stage more advanced showing thickening of the scales.
Fig. 3. Flower stage still further advanced; scales beginning to grow over the ovules.
Fig. 4. A young deformed berry; (a) Top of an ovule not covered by the scales, to be the opening by which the mites pass back and forth; (b) The normal ovule nearly covered by the scales.
Fig. 5. Longitudinal section of a young deformed berry showing the early work of the mites.
Fig. 6. Mature deformed berry; (a) Opening by which the mites pass back and forth.
Fig. 7. Egg of *Eurytoma juniperinus* containing embryo.
Fig. 8. Breast bone of the Cecidomyid larva.

PLATE XIII.

Fig. 1. Female of *Eurytoma juniperinus*, (enlarged and modified from a drawing of *E. tylodermatis*, after U. S. Dept. of Agriculture).
Fig. 2. Stigmal club of *E. juniperinus*.
Fig. 3. Abdomen of *E. juniperinus*.
Fig. 4. Wing of *Rhagoletis juniperinus*.
Fig. 5. Antenna of *R. juniperinus*.
Fig. 6. Side view of head of *R. juniperinus*.
Fig. 7. Head of *R. juniperinus* from in front.

PLATE XIV.

Fig. 1. Larva of *E. juniperinus*.
Fig. 2. Head of larva of *E. juniperinus*, from in front.
Fig. 3. Mandible of *E. juniperinus*.
Fig. 4. Trachael system of larva of *E. juniperinus*.
Fig. 5. Pupa of *E. juniperinus*.
Fig. 6. Larva of *Geniocerus juniperi*.
Fig. 7. Mouth parts of *G. juniperi* seen under high power.
Fig. 8. Pupa of *G. juniperi*.

PLATE XV.

Fig. 1. Adult male parasite of *A. alternatella*. Fam. Encyrtidæ.
Fig. 2. Antenna of same.
Fig. 3. Stigmal club of same.
Fig. 4. Stigmal club of parasite *A. alternatella*. *Secodella sp.*
Fig. 5. Antenna of *Secodella sp.*
Fig. 6. Larva of same.
Fig. 7. Head from in front of larva of same.
Fig. 8. Male antenna of *G. juniperi*.
Fig. 9. Larva of *Geniocerus marcovitchi*.
Fig. 10. Pupa of *G. marcovitchi*.
Fig. 11. Undetermined larva sometimes found in the berries of *J. virginiana*.
Fig. 12. Mouth parts of same.
Fig. 13. Egg of *G. marcovitchi*.
Fig. 14. Egg of *G. juniperi*.
Fig. 15. Mandible of *G. juniperi*.

PLATE XVI.

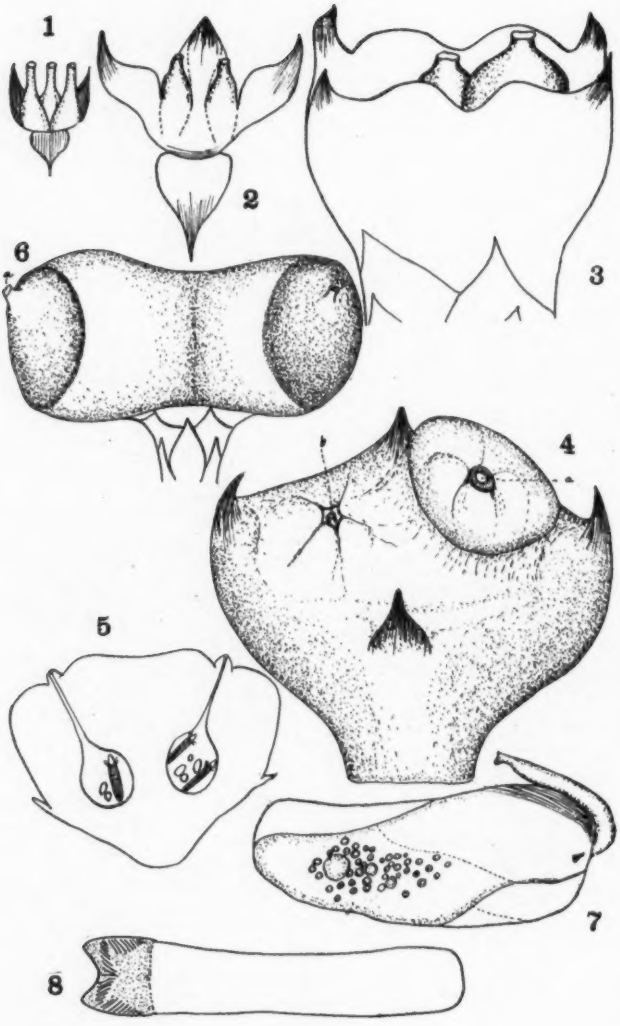
Fig. 1. Larva of *R. juniperinus*.
Fig. 2. Side view of cuadal tip of larva of *R. juniperinus*.
Fig. 3. End of larva of *R. juniperinus*.
Fig. 4. Head end of larva of *R. juniperinus*.
Fig. 5. Sensory papilla of *R. juniperinus*.
Fig. 6. Anterior spiracle of *R. juniperinus*.
Fig. 7. Tip of one of the lobes of the anterior spiracle of *R. juniperinus* (enlarged).
Fig. 8. Egg of *R. juniperinus*.
Fig. 9. Head end of larva of *R. juniperinus* from beneath.
Fig. 10. Stigmal plate of *R. juniperinus*.
Fig. 11. Cephalo-pharyngeal skeleton of *R. juniperinus*.

PLATE XVII.

Fig. 1. Larva of *Argyresthia alternatella*. Kearf.
Fig. 2. Mandible of larva of *A. alternatella*.
Fig. 3. Thoracic leg of larva of *A. alternatella*.
Fig. 4. Parasitized larva of *A. alternatella*, showing three mature pupa of the Encyrtid.
Fig. 5. Hooks on prolegs of *A. alternatella*.
Fig. 6. Longitudinal section of a berry showing (a) Young larva of *A. alternatella* in the third layer of the ovule; (b) Egg of *E. juniperinus* in burrow of mites.
Fig. 7. Diagram showing the location of setæ on the first abdominal segment of *A. alternatella*.

PLATE XVIII.

Fig. 1. Labium of larva of *A. alternatella*.
Fig. 2. Maxilla of larva of *A. alternatella*.
Fig. 3. Antenna of larva of *A. alternatella*.
Fig. 4. Pupa of *A. alternatella*.
Fig. 5. Longitudinal section of a mature deformed berry.
(a) Larva of *E. juniperinus*.
(b) Larva of *G. juniperi*.
(c) Decidomyid larva.
(d) Mite.
Fig. 6. A young berry showing position of eggs of *A. alternatella*.
Fig. 7. Egg of *A. alternatella*.



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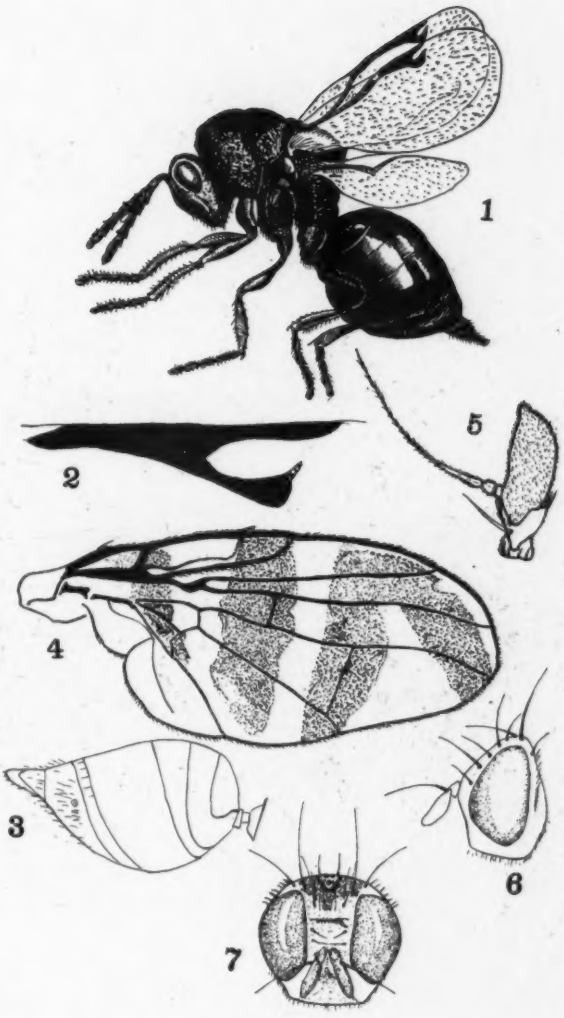

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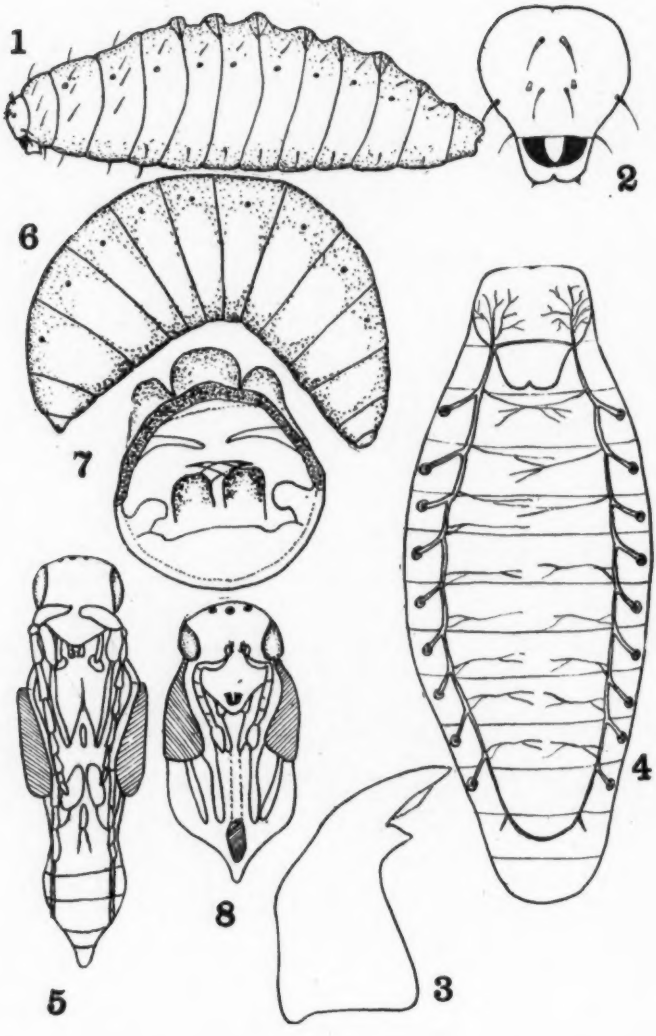

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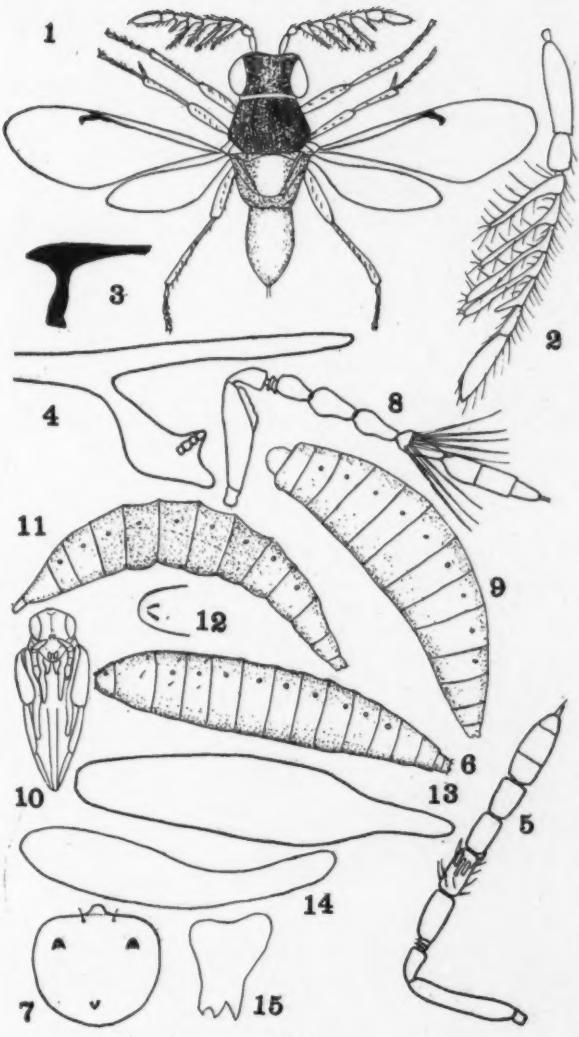

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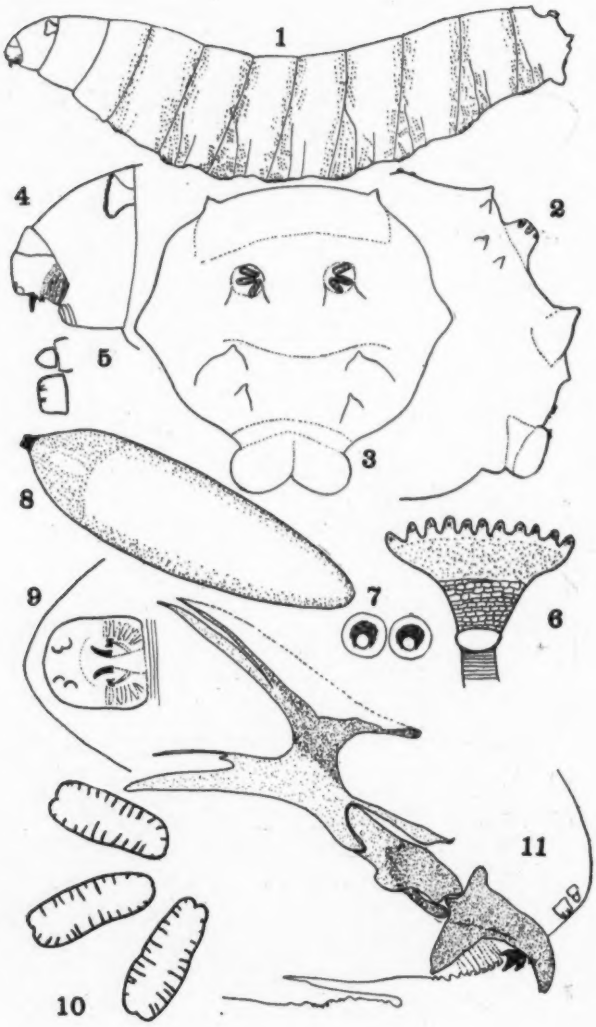

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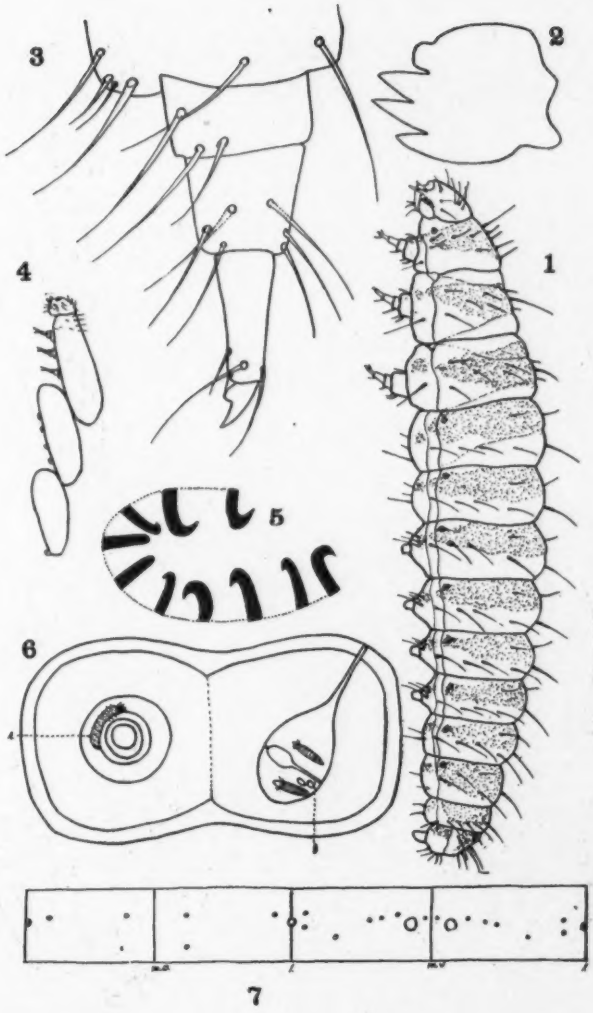

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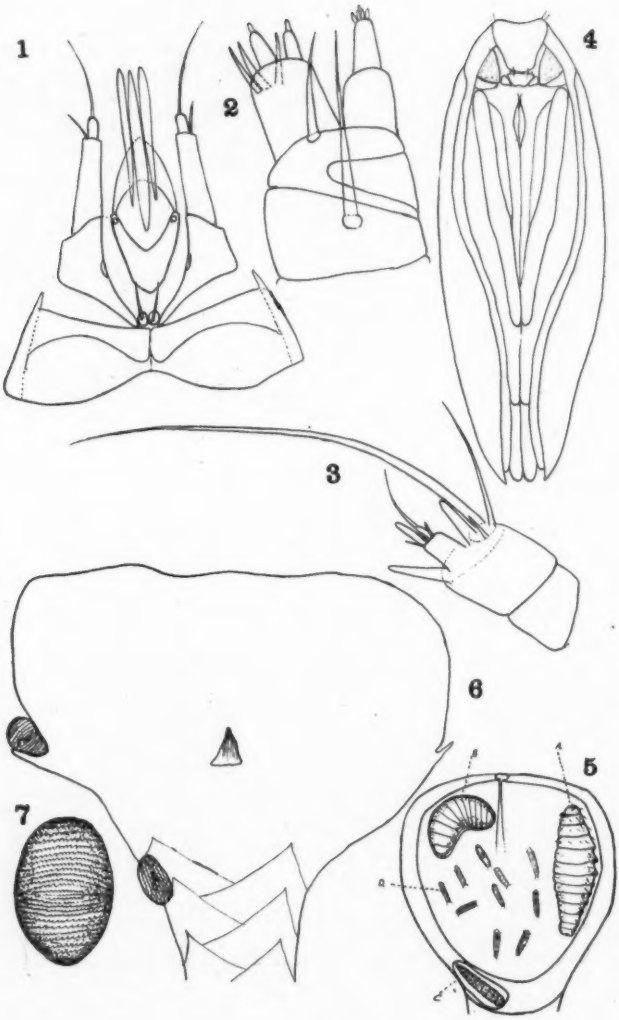


S. Marcovitch.

SOME NEW SPECIES OF JASSOIDEA.

S. E. Crumb,
U. S. Bureau of Entomology.

This paper includes descriptions of twelve new species of Jassoidea mostly from Tennessee, and a description of the male of *Deltocephalus mendosus* Ball.

Deltocephalus visendus n. sp. (Pl. XIX, figs. 3, 4).

Pale cinereous, resembling *reflexus* in form and markings. Face not distinctly bicolored. 3.4 to 4.2 mm. long, 1. mm. broad.

Vertex flat, as long as its width between the eyes, nearly two and one-half times as long on middle as next eye, nearly twice as long as the pronotum, clypeus short, tapering, broad, apex broadly truncate, one-third the length of the front, pronotum twice wider than long. Elytra in form and venation as in *reflexus*, but with two cross nervures, claval veins confluent through the middle fourth of the outer vein.

Color: General color pale cinereous, vertex with the apex white, margined laterally with black, an orange line from apex toward the ocelli, ocelli red, a pair of median transverse bars on vertex, another pair of convergent submedian spots near the base and six longitudinal stripes on the pronotum, pale brownish fuscous, elytra with black spots outside the anterior juncture of the claval veins, behind the first cross vein and in the third apical cell. Face black above, becoming brownish fuscous below.

♀ Ultimate ventral segment twice as long as the penultimate, twice as broad as long, side margin narrowed from before the middle, the lateral angles produced, short, roundingly lobate, the posterior margin gently emarginate, the median fourth subangularly produced and minutely notched at apex, surpassed by the lateral lobes. Segment pale with a dark, median apical area.

♂ Valve triangular, twice as broad as long, three times as long as ultimate segment; plates twice as long as valve, nearly one-half longer than broad, side margin nearly straight, convergent, abruptly constricted about one-third from the apex, beyond which the tips are nearly parallel, blunt and minutely excavated on the inner margin. Pygofers about one-fourth longer than the plates, distinctly compressed from near the base.

Described from two males and two females collected by the author, November 19, 1914, at Jacksonville, Florida.

Deltocephalus funabulus n. sp. (Pl. XIX, figs. 17, 18).

White, resembling *albidus*, with all the veins of the elytra margined with dark fuscous, face black above and abruptly pale yellow below. 3.7 to 4. mm. long, 1.1 to 1.5 mm. broad.

Vertex flat, one-fourth longer than its width between the eyes, twice as long on middle as next eye, one-half longer than the pronotum, tip blunt; clypeus tapering, truncated at apex, cheeks broad, slightly emarginated beneath the eyes, the lateral angles obscure; pronotum twice broader than long, elytra narrow, appressed, as long as abdomen, with the claval veins usually separate or united only by a cross nervure, two cross nervures in the corium, central anteapical cell simple, venation as in *albidus*.

Color: General color white, markings closely resembling *albidus*, vertex yellow with margin and apex white, apex margined antero-laterally by two small, black dots and posteriorly by a larger black dot; ocelli red; a narrow marginal line from apex toward ocellus, orange, a pair of slender median transverse bars and a pair of convergent curved submedian basal spots, continuing the submedian thoracic stripes, pale brownish fuscous. Thorax with four broad longitudinal pale fuscous stripes. Elytra with nervures white, narrowly margined with dark fuscous. Venter dark. Last ventral segment of the female concolorous with the remainder of the venter.

♀ Last ventral segment three times as long as the penultimate, three-fifths as long as broad, side margins distinctly narrowed from before the middle, between their angular posterior limits the posterior margin is gently, roundingly emarginate with a large rounded median lobe slightly exceeded by the lateral angles, and bearing a small apical notch and a pair of longitudinal black dashes.

♂ Valve rounded, two and one-half times broader than long; plates one and one-half times longer than valve, three-fifths as long as broad, lateral margin convex, tips blunt, slightly divergent, pygofers very large, somewhat depressed, inflated, one and one-half times broader and three times as long as the plates, with a broad, dark fuscous area behind the plates, the inner margins pale.

Described from thirty-three specimens, taken at Galena, Kansas, and Clarksville, Tennessee. The former taken during October on *Aristida oligantha*, the latter taken during September from *Aristida gracilis*. Collected by the author.

Deltocephalus mendosus Ball. (Plate XIX, fig. 21).

This species was described from the female only (Can. Ent., Vol. LXIII, p. 202) as a variety of *fraternus*. Recently I have collected a single male having the peculiar markings of the vertex and the venation of *fraternus*, but differing widely from the male *fraternus* in the genitalia. If, as it seems quite probable, this is the male of *fraternus* this variety is certainly worthy of specific rank. The male is described below:

♂ Valve large, acutely triangular, somewhat upturned at tip, as long as broad; plates broader than valve at base, nearly as long as broad, exceeding valve by nearly half its length, the lateral margins irregularly convex, tips oblique, rounded; pygofers exceeding the plates by nearly their own length, without finger-like appendages found in

fraternus and excavated and inflated basally for the reception of plates, the apical third produced into a slender, cylindrical process. 3.6 mm. long, 1.2 mm. broad.

Deltocephalus pyrops n. sp. (Pl. XIX, figs. 15, 16).

Vertex Platymetopius-like, elytra white, the venation outlined with dark fuscous, the costal area canary yellow. 3.6 to 4. mm. long, 1.3 mm. broad.

Vertex flat, acutely angulate, slightly recurved from near the base, twice as long as width between the eyes, nearly three times as long on middle as next eye, two and one-half times as long as the pronotum, face and especially the front strongly convex, not quite one and one-half times longer than broad, front narrow, four times as long as the clypeus, clypeus tapering, exceeded by the tips of the genæ, margin of genæ strongly oblique and nearly uniformly convex from eye to clypeus, pronotum nearly two and one-half times wider than long, elytra nearly as long as abdomen, narrowed slightly toward the tip, claval veins and central anteapical cell variable.

Color: Vertex, pronotum and scutellum pale brownish yellow; vertex with oval apical area white, margined laterally with black and posteriorly with fuscous, two pairs of transverse, fuscous dashes on the disc, one anterior to and the other posterior to the ocellus; ocelli, eyes and often the ovipositor bright red; pronotum with a fuscous band back of each eye; elytra white, the nervures narrowly outlined with dark fuscous, the costal area pale canary yellow; venter pale; face pale yellow, broadly margined above, excepting the tip of front which is white, with dark fuscous, which on the front encroaches upon the yellow in the form of three or four well marked teeth.

♀ Ultimate ventral segment nearly twice as long as the penultimate, one and one-half times as broad as long, narrowed posteriorly to the distinct lateral angles, between which the posterior margin is obliquely truncated, to near the middle where it is broadly incised nearly one-half way to the base, the apex of this incision bears a triangular tooth, the tooth and surrounding area deep black.

♂ Valve subangulate, twice as broad as long; plates one and one-half times as long as the valve, and one and one-half times as broad as long, their common outline broadly oval, the sides rounding strongly to the blunt, slightly divergent tips, pygofers large, one and one-half times as broad and nearly two and one-half times as long as plates, with a pair of arcuated fuscous lines and more or less red behind the plates.

Described from thirty-six specimens collected September, 1914, by the author at Clarksville, Tennessee, on *Aristida gracilis*.

Deltocephalus arundineus n. sp. (Pl. XIX, figs. 11, 12).

Near *inimicus*, but in shape and markings resembling a *Scaphoideus* of the *sanctus* group. 3.3 to 3.7 mm. long, 1.2 mm. broad.

Vertex nearly flat, one and one-half times longer than width between eyes, three-fifths as long at eye as on the middle, as long as pronotum, margin thick, frontal sutures convex, clypeal suture obsolete, clypeus parallel margined, pronotum twice as wide as long, venation of elytra much as in *inimicus*, claval veins united by a cross vein near the middle of the inner claval vein, outer vein united to claval suture by a few supernumerary veins near the apex, second cross nervure present, central anteapical cell constricted and divided by a cross vein, outer anteapical cell rectangular at apex, elytra longer than abdomen, appendix broad, more nearly truncate at apex than in *inimicus*.

Color: Vertex white, four marginal dots and two smaller ones next the eye black, the apical pair triangular, a large irregular spot on the disc narrowly connected with the black dots next the eye and a pair of convergent dashes near the base, fuscous brown, ocelli white; pronotum fuscous, the anterior margin and three longitudinal stripes pale, anterior margin with a dark fuscous spot behind each eye, and a paler fuscous area on the middle; elytral venation white, margined with fuscous, basal third of clavus white, an elliptical fuscous area at each angle, an oblong area next the claval suture, a spot on the costa, and the third apical cell, black, all these black markings being the accentuated portions of a common cruciate fuscous apical figure and a fuscous more basal saddle.

♀ Ultimate ventral segment three times as long as penultimate, nearly twice as broad as long, roundingly narrowed posteriorly, the lateral angles produced, lobate, the posterior margin obliquely excavated one-fourth to base of segment, with the apex of excavation convexly subtruncate, and one-third the width of the segment.

♂ Valve rounded posteriorly, twice longer than ultimate segment, nearly three times as broad as long, convex anteriorly; plates four times as long as valve, more than one-half longer than broad, concavely narrowing to the attenuate tips which equal the pygofers. Pygofers very densely clothed with bristles.

Described from ten females and eight males taken on *Arundinaria tecta*, July and August, 1914, by the author at Clarksville, Tennessee.

Deltocephalus vinnulus n. sp. (Pl. XIX, figs. 1, 2).

Related to *compactus* with very similar genitalia in both sexes, but much paler. 2. to 2.6 mm. long, 1. mm. broad.

Vertex convex, slightly longer than width between eyes, nearly one-half longer on middle than next eye, margin thick, tip blunt, as long as pronotum, clypeus parallel margined, suture obsolete, pronotum twice as wide as long, elytra hyaline obliquely subtruncate at tip, venation pale, claval veins separate, a few supernumerary cross veins along the sutural margin, central anteapical cell divided by a cross vein, outer anteapical cell rectangular at apex.

Color: Vertex, including ocelli, white, the anterior half black, bearing a white, squat, T-shaped figure, the base of which is formed by a

white dot on the apex, a fuscous cloud on the disc, remainder of insect dorsally and ventrally, excepting the black upper half of face, an uniform, pale yellowish brown, the cells of elytra, the pronotum and venter sometimes faintly infuscated. The macropterous form is the more infuscated.

♀ Last ventral segment of abdomen two and one-half times as long as penultimate, nearly twice as broad as long, distinctly angulate anteriorly with a second membrane excavated nearly to the base as in *compactus*, outer membrane strongly emarginate laterally from the base, exposing a rounded lobe of the inner membrane, the lateral angles obsolete, the posterior margin gently convex with a pair of median pale, fuscous triangles.

♂ Valve convex, twice as broad as long, strongly convex on both anterior and posterior margins, the posterior margin subangulate; plates twice as long as valve, as broad as valve at base, as long as broad, strongly, concavely narrowing to the acute tips, which equal the apex of the pygofers. Pygofers distinctly broader than plates and set with coarse, infuscated bristles.

Described from five males and two females taken September, 1914, by the author at Clarksville, Tennessee, on *Andropogon virginicus*. In the macropterous form the elytra are much longer than the abdomen, while in the brachypterous form the elytra are distinctly shorter than the abdomen.

Deltocephalus vicilinus n. sp. (Pl. XIX, figs. 5, 6).

Resembling *sylvestris*, but smaller, male plates broadly truncated. 2.4 to 2.6 mm. long, .7 mm. broad.

Vertex flat, as long as width between eyes, one-half longer on middle than next eye, strongly angulate, long as pronotum, front very convex, clypeus tapering, rounded at apex, which exceeds the genæ, pronotum twice as wide as long, venation as in *sylvestris*, elytra exceeding abdomen, narrowing posteriorly.

Color: As in *sylvestris*, vertex pale greenish, with a median longitudinal pair of brownish stripes, apex, front margin, and the median stripe whitish, a curved fuscous line from apex toward the black ocelli, pronotum green, paler anteriorly with six pale, fuscous stripes, elytra pale olive green, infuscated apically, the venation pale, front infuscated gray with light arcs, clypeus and genæ pale.

♀ Ultimate ventral segment one and one-half times as long as the penultimate, twice as broad as long, strongly convex anteriorly, posterior margin gently emarginate, the median third slightly subtruncately excavated. A transverse black line at middle.

♂ Valve rounded posteriorly, three times as broad as long; plates distinctly broader than the valve, about three and one-half times as long as valve, nearly as long as broad, as broad as pygofers at base, side margins nearly straight, tips roundingly truncated, one-half as broad as base, a common triangular basal area yellow, margined with fuscous, pygofers slightly exceeding plates and densely clothed with coarse bristles.

Described from nine females and three males collected by the author October 8, 1914, at Clarksville, Tennessee, from small grasses on dry upland.

Athysanus (Stirellus) villicus n. sp. (Pl. XIX, figs. 24, 25).

Near *punctatus*. With two large, round, black spots on anterior margin of vertex next eye. An orange or fuscous brown band on posterior half of pronotum. Female ovipositor rather strongly exserted. 2.6-3. mm. long and 1. mm. broad.

Vertex convex, as long as width between the eyes, as long as pronotum, one-fifth longer on middle than at eye, bluntly angulate, margin blunt, front convex in both diameters, rapidly narrowing to the parallel margined clypeus. Pronotum two and one-third times as broad as long. The elytra subhyaline, narrowed toward the apex, venation weak, distinct, the central anteapical cell divided by a cross vein.

Vertex, anterior half of pronotum and scutellum yellow, posterior half of the pronotum and the elytra pale orange or infuscated brown, two large, round, black spots on anterior margin of vertex next the eye, and two minute, fuscous points at apex; venation pale, face yellow, the front more or less infuscated with a median stripe and lateral arcs pale, a black point beneath each ocellus, venter mostly pale.

♀ Ultimate ventral segment of abdomen one and one-half times as long as penultimate, twice as broad as long, lateral angles rounded, posterior margin gently emarginate, but sometimes appearing angularly excavated, owing to the curvature, strongly curved over the ovipositor, with a small, rounded median tooth. Ovipositor rather strongly exserted.

♂ Valve convex, twice as long as preceding segment, strongly convex on anterior margin, subangulate posteriorly, over twice as broad as long; plates twice as long as valve, nearly as long as broad, side margin nearly straight, tips acute, slightly exceeded by the stout pygofers which are heavily clothed with bristles. A basal median fuscous line on each plate.

Described from seven females and ten males, collected by the author at Clarksville, Tennessee, September and October, 1912, on *Aristida gracilis*, in company with *Deltocephalus pyrops*.

Phlepsius optatus n. sp. (Pl. XIX, figs. 13, 14).

Very near *fulvidorsum* in shape, size and genital characters, but paler and differing in details. Length 5. to 6. mm., breadth 1.6 mm.

Vertex convex, nearly three and one-half times as broad as middle length, about one-fifth longer on apex than next eye, one-third as long as pronotum, the margin blunt, front three times as broad between ocelli as at clypeus, slightly longer than broad, convex, the sutures convex, elytra long, appressed at tip.

Color: Vertex, pronotum and scutellum pale yellowish, inscribed with fuscous, the impressed line of vertex and two points on posterior margin, an indefinite mark behind each eye, a pair of spots near apex of scutellum and two points midway between these and the basal angles, black; elytra milky white with a narrow, creamy white submargin along costa, the basal three-eighths very sparsely, the remainder more densely, inscribed with fuscous, showing a tendency to form a transverse band across the tip of the outer claval vein, a spot at tip of outer claval vein, another beyond and outside tip of clavus, several small spots along costa toward the tip and at tip of elytra, black; face pale yellow, fuscous inscribed; legs white, two bands on femora and the insertion of the spines black; venter white.

♀ Last ventral segment twice as long as preceding, one-half wider than long, one-half broader at base than at apex, lateral lobes rounded subangulate, posterior margin roundingly emarginate one-fourth to base of segment, with a pair of minute submedian lobes between which the margin is notched, a transverse curved black mark each side of middle; pygofers with short, stout, white bristles set in black points; ovipositor slightly exceeding pygofers.

♂ Valve nearly as long as preceding segment, three and one-third times as broad as long, convex anteriorly, subangulate posteriorly; plates nearly five times as long as valve, one-fifth longer than broad, concavely narrowing from near the base to the broad, subtruncate tips which are exceeded slightly by the pygofers.

Described from three females and three males, collected by the author at Clarksville, Tennessee, May, June and July, 1914.

Eutettix ziczac n. sp. (Pl. XIX, figs. 19, 20).

Vertex nearly as long as wide and distinctly angled with a zigzag, fuscous, longitudinal band on elytra. 5. mm. long, 1.6 mm. broad.

Vertex, basal three-fifths shallowly transversely depressed, slightly wider than middle length, one-half longer on apex than next eye, distinctly angulate, angle between vertex and front acute, elytra long, neither flaring nor appressed, one cross nervure.

Color: Vertex pale yellow, washed with orange, four points on anterior margin, a reticulate area on disc and four marks along posterior margin, black, pronotum pale olive, irrorate with black, scutellum yellow, washed with orange with black markings, elytra white, mottled sparingly with orange, venation orange, overlaid with fuscous dots, the fuscous reticulation disposed in a zigzag stripe extending along the scutellar margin and basal three-fourths of clavus and the tip of the wing branching to meet the costa twice between the cross nervure and the base of the central anteapical cell, and once opposite the apex of the outer anteapical cell. Face yellow, irrorated with black. Beneath pale.

♀ Last ventral segment one-half longer than the preceding, nearly two and one-half times as broad as long, gently angularly emarginate, subtruncate.

Described from one female taken at Sabinal, Texas, April, 1910, by the late F. C. Pratt.

Chlorotettix nacreosa n. sp. (Pl. XIX, figs. 9, 10).

An uniform pearly white above and below in the female. Deep orange in the male. 5. to 5.5 mm. long, 1.6 mm. broad.

Vertex flat, one-third broader between eyes than middle length, one-half longer on apex than at eye, three-fourths as long as pronotum, distinctly angulate, profile of face and vertex acute, lorae remote from margin of cheek.

Color: ♀ pale, uniform grayish subiridescent white both dorsally and ventrally, the eyes green, spines on legs brownish, ovipositor dark, elytra faintly tinged apically with brownish, venation pale. ♂ Uniform deep orange above and below, eyes green.

♀ Ultimate ventral segment twice as long as the preceding, twice as broad as long, posterior margin triangularly emarginate nearly one-half way to base. The outline broken by a pair of rounded, submedian lobes narrower and shorter than the lateral lobes and with their outline continued across the lateral lobe by a suture.

♂ Valve strongly convex anteriorly, rounded posteriorly, twice as long as preceding segment, nearly two and one-half times as broad as long; plates one-fifth longer than broad, nearly two and one-half times as long as valve, transversely convex, the margin upturned, tips bluntly rounding, sub-truncate, equalling all but the brown apical styles of the pygofers.

Described from eighteen females and four males, collected by the author, July 29–30, 1914, from *Arundinaria tecta*, at Clarksville, Tennessee.

Chlorotettix vacuna n. sp. (Pl. XIX, figs. 22, 23).

Size and general appearance of *Balli*, but with genitalia distinct. Length 6. to 6.5 mm., breadth 1.6 mm.

Vertex convex, one and one-half times broader between eyes than middle length, one-third longer on middle than next eye, bluntly subangulate, margin thick.

Color: Vertex, anterior margin of prothorax and the scutellum yellowish, tinged with green, prothorax brownish, elytra subhyaline, brownish, front tinged with orange, venter green.

♀ Ultimate ventral segment two and one-half times as long as penultimate, one and one-half times as broad as long, not tectiform, but uniformly transversely convex from the lateral margins, closely applied to the pygofers, membranous, intricately rugose, lateral margins but little narrowed, the posterior angles distinct, the posterior margin occupied by a broad, sinuated, triangular excavation three-fourths to base of segment, the apical half of the excavation straight margined.

♂ Valve as long as last ventral segment, twice as broad as long, subangulate posteriorly; plates three times the length of valve, two-thirds as broad as long, the outer margin convexly narrowing to the subacute tips, their common figure an elongate oval.

Described from four males and two females collected by the author September 3–4, 1914, Clarksville, Tennessee.

Chlorotettix vivida n. sp. (Pl. XIX, figs. 7, 8).

Apparently related to ***minima*** Baker. 5.5 mm. to 6. mm. long, 1.5 mm. broad.

Vertex convex, one and one-half times as broad between the eyes as long, five-eighths as long at eye as at middle, distinctly angulate, the margin thick excepting at the slightly conical apex, venation indistinct.

Color: Head, thorax and scutellum pale brownish, usually with a greenish tinge, elytra subhyaline, pale green with a brownish tinge more distinct apically.

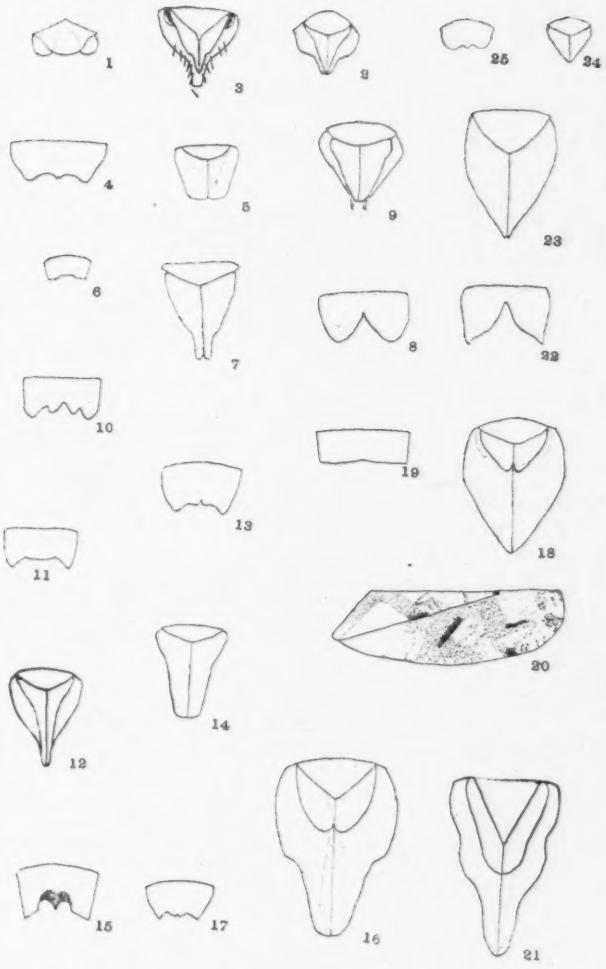
♀ Ultimate ventral segment of abdomen twice as long as penultimate, twice as broad as long, lateral angles rounded, posterior margin broadly, somewhat sinuately triangularly excavated to about one-half the length of the segment, with a small apical notch.

♂ Valve as long as preceding segment, four times as broad as long, convex posteriorly; plates nearly four times as long as valve, nearly as broad as long, slightly narrower than valve at base, convexly narrowing three-fourths their length, the apical fourth produced into two narrow, parallel margined processes, pygofers equalling plates, densely clothed with spines apically.

Described from three males and nineteen females taken May, July, August and September, 1914, at Clarksville, Tennessee, by the author.

EXPLANATION OF PLATE XIX.

Fig. 1. Deltocephalus vinnulus, last ventral segment of female.
Fig. 2. Deltocephalus vinnulus, male genitalia.
Fig. 3. Deltocephalus visendus, male genitalia.
Fig. 4. Deltocephalus visendus, last ventral segment of female.
Fig. 5. Deltocephalus vicilinus, male genitalia.
Fig. 6. Deltocephalus vicilinus, last ventral segment of female.
Fig. 7. Chlorotettix vivida, male genitalia.
Fig. 8. Chlorotettix vivida, last ventral segment of female.
Fig. 9. Chlorotettix nacreosa, male genitalia.
Fig. 10. Chlorotettix nacreosa, last ventral segment of female.
Fig. 11. Deltocephalus arundineus, last ventral segment of female.
Fig. 12. Deltocephalus arundineus, male genitalia.
Fig. 13. Phlepsius optatus, last ventral segment of female.
Fig. 14. Phlepsius optatus, male genitalia.
Fig. 15. Deltocephalus pyrops, last ventral segment of female.
Fig. 16. Deltocephalus pyrops, male genitalia.
Fig. 17. Deltocephalus funabulus, last ventral segment of female.
Fig. 18. Deltocephalus funabulus, male genitalia.
Fig. 19. Eutettix ziczac, last ventral segment of female.
Fig. 20. Eutettix ziczac, left elytron.
Fig. 21. Deltocephalus mendosus Ball, male genitalia.
Fig. 22. Chlorotettix vacuna, last ventral segment of female.
Fig. 23. Chlorotettix vacuna, male genitalia.
Fig. 24. Athysanus (Stirellus) villicus, male genitalia.
Fig. 25. Athysanus (Stirellus) villicus, last ventral segment of female.



S. E. Crumb.